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SATURN S-IVB-201 STAGE ACCEPTANCE FIRING TEST PLAN

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PREPARED BY:
DOUGLAS AIRCRAFT COMPANY, INC.
SATURN S-IVB/IB TEST PLANNING
AND EVALUATION COMMITTEE

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MODEL DSV-4B

J.P. Monigal

APPROVED BY: J.P. MONIGAL
BRANCH CHIEF, SYSTEMS DEVELOPMENT
SACRAMENTO TEST CENTER

A. G. Puglisi

APPROVED BY: A.G. PUGLISI
MANAGER, SATURN SYSTEMS DEVELOPMENT

O. S. Tyson

APPROVED BY: O.S. TYSON
RESIDENT MANAGER, SACRAMENTO TEST SITE
I-I/IB-DAC/SACTO

DOUGLAS MISSILE & SPACE SYSTEMS DIVISION

ABSTRACT

Douglas Aircraft Company Report No. SM-46801: Saturn S-IVB-201 Stage Acceptance Firing Test Plan documents the requirements of the acceptance firing test program for the Saturn S-IVB-201 stage of the Saturn IB vehicle number SA-201. The acceptance firing test objectives are defined; each includes the established acceptance criteria for the satisfactory achievement and buyoff of the objective. The differences between the stage test configuration and the flight configuration are delineated. The test program will be accomplished by the Douglas Aircraft Company at the Sacramento Test Center, Complex Beta and Complex Gamma test facilities, under National Aeronautics and Space Administration Contract NAS7-101.

DESCRIPTORS

Acceptance Testing	SA-201 Vehicle
Auxiliary Propulsion System	Saturn S-IVB/IB Stage
DACO	Sacramento Test Center
J-2 Engine	Static Firing Test

PREFACE

This report, prepared under National Aeronautics and Space Administration Contract NAS7-101, is issued in accordance with the contractural requirements of Douglas Report No. SM-41412: General Test Plan Saturn S-IVB System.

The purpose of this report is to document the Saturn S-IVB-201 stage acceptance firing test plan. The information contained herein will serve as a test directive for the Douglas Sacramento Test Center when preparing test request memoranda.

The report includes information on the acceptance firing test objectives for the stage, confidence firing objectives for the APS (auxiliary propulsion system) modules, research and development test objectives, stage and APS module configurations, instrumentation and data requirements, evaluation and documentation requirements, facility and ground support equipment, and the test program.

This test plan, prepared by the Huntington Beach Space Systems Center TP&E Committee and coordinated with the Sacramento Test Center TP&E Committee, is a DAC - NASA coordinated document signed by DAC and NASA/MSFC representatives. The test plan will be the buyoff document for acceptance. At the completion of the evaluation meeting, buyoff signatures will be required by representatives of both agencies.

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SECTION 1

INTRODUCTION

1. INTRODUCTION

This test plan documents the firing portion of the Saturn S-IVB-201 stage acceptance test program to be conducted at the Douglas Sacramento Test Center. The overall test program will be conducted by Douglas personnel during a scheduled 15-week period. The purpose of the test program will be to demonstrate that the S-IVB-201 stage systems, during a full duration firing, perform adequately at sea level conditions prior to shipment of the stage to the Kennedy Space Center.

1.1 Program Definition

The acceptance firing test program will be conducted at the Complex Beta test facility except for the confidence firings of the two APS (auxiliary propulsion system) flight modules at the Complex Gamma test facility.

The stage acceptance firing test will be limited to those phases of stage production testing during which the acceptance objectives of this test plan will be achieved. This will include that part of the firing countdown from propellant loading through shutdown and securing of the systems, the postfiring structural integrity inspection, and the evaluation of data acquired during the countdown. The automatic countdown used will conform as closely as possible to the S-IVB stage sequence and time allotments of the KSC (Kennedy Space Center) SA-201 vehicle flight countdown. All flight systems will be active to the maximum extent possible during firing. Those stage systems which will be inactive or altered during firing are delineated in the configuration section of this report. Complex Beta GSE (ground support equipment) and facilities will be employed fully to safely control and monitor the test operations.

The APS module confidence firings will be confined to that part of the countdown during which the confidence firing objectives of this test plan will be achieved. This will be comprised of manual propellant loading, pressurization, firing, system securing, and evaluation of data acquired during the countdown. The countdown operations will be manually controlled. Complex Gamma GSE and facilities will be employed fully to safely control and monitor the test operations.

1.1.1 Stage Acceptance Firing Test Objectives

The stage acceptance firing test objectives will include demonstrations of proper performances and operations of the propulsion system, pneumatic system, pressurization system, electrical control and power system, hydraulic system, data acquisition system, propellant utilization system, GSE to S-IVB stage interfaces applicable to KSC, and S-IVB stage to Saturn IB vehicle interfaces. Verification will be made of stage structural integrity. Demonstrations will also be made to verify proper execution of controlling procedures and operations pertinent to KSC.

1.1.2 APS Module Confidence Firing Test Objective

The confidence firing objective for each APS module will be to verify that the module can be loaded and pressurized, responds to flight-type firing commands, and has operating characteristics compatible with design requirements.

1.1.3 Stage Research and Development Objectives

Additional objectives of research and development nature will serve to determine the stage acoustic, vibration and thermodynamic environments during firing.

1.2 Background

The findings and experiences gained from the S-IVB Battleship, the S-IVB/IB APS module development, and the S-IVB-F (Facility Checkout Stage) test programs, conducted at STC (Sacramento Test Center), have been designed into the S-IVB-201 stage acceptance test program. The Battleship and APS module programs provided information for optimizing stage, module, and GSE design and for developing handling and checkout procedures. The S-IVB-F stage was used during the successful checkout of the Beta III facility and associated GSE. Two propellant loading exercises were accomplished, one under the control of the automatic GSE system.

The S-IVB-201 stage will be assembled at the Huntington Beach Space Systems Center. The stage, less both APS modules, will be transported to the Sacramento Test Center and installed on Complex Beta test stand III for stage testing. The preparations for acceptance firing will include manual and automatic subsystem checkouts, an integrated systems test, a simulated static firing countdown, and a preliminary propellant loading test. A start bottle blowdown test will be scheduled during the latter test.

On arrival at STC, the S-IVB-201 stage APS flight modules will be transported to Complex Gamma for module confidence firings. The preparations for APS module firings will include electrical continuity and resistance checks of the instrumentation and control systems, checkout of the data acquisition system, and leak and functional checkout of the module systems.

SECTION 2

TEST PROGRAM

2. TEST PROGRAM

This section describes the acceptance test program for the S-IVB-201 stage to be accomplished at the Sacramento Test Center. The program is divided into five phases, as shown in figure 2-1.

a. Prefiring checkout and operations

b. Preliminary propellant loading test

c. Full duration acceptance firing

d. Post-firing checkout and operations

e. APS module confidence firing program at Complex Gamma

A more detailed description of the prefiring and post-firing checkout operations is contained in DAC drawing No. 1B55303, S-IVB-201 Stage End Item Test Plan.

2.1 Prefiring Checkout and Operations

2.1.1 Automatic Checkout Equipment Verification

This task will verify point-to-point patching and functional operation of the integrated GSE (ground support equipment), using the GSE test set to simulate stage functions. This test will be accomplished prior to mating umbilicals to the stage.

2.1.2 Stage Installation

This task will include positioning of the stage, removal of environmental covers, installation of lifting gear, hoisting, and installation of stage on the dummy aft interstage in Complex Beta test stand III.

2.1.3 Receiving Inspection

This task will include a visual inspection of stage for damage to tankage, structure, wiring, and components in shipment and will also establish configuration.

2.1.4 Stage Preparation and Modifications

This task will include installation of access kits, the connection of pneumatic pressure monitoring gages to stage sense ports, installation of hardwire instrumentation, and completion of necessary manufacturing and modification packages.

2.1.5 Bulkhead Vacuum Check

This task will include the installation and setup of the bulkhead monitoring and evacuation system and the verification of the bulkhead leak-tight integrity. Gas samples for analysis will be taken.

2.1.6 Umbilical Resistance Check

This task will include a resistance check of stage circuitry as seen through the umbilical connector pins. This will assure the absence of short circuits and will indicate stage readiness for power. The task will terminate with installation of electrical umbilicals.

2.1.7 Engine Alignment

This task will be performed optically to verify that the exit plane of the J-2 engine thrust chamber is properly aligned with respect to the stage structure. The actuators are also mechanically shortened to a computed value to compensate for mechanical looseness in the vertical position and for thrust compression when the engine is firing.

2.1.8 Forward Skirt Thermo-Conditioning Subsystem Checkout

This task will include the leak checking, filling, bleeding, and functioning of the cold-plate conditioning system.

2.1.9 Aft Skirt and Interstage Thermo-Conditioning and Purge System Checkout

This task will verify proper air/gas distribution and pressure drops within the aft skirt manifold and APS ducts and will verify correct operation of the test stand portion of the system. Purge pressures will also be verified.

2.1.10 Forward and Aft Skirt Purge Checkout

This task will verify the correct operation of the combined test stand and stage portions of this system.

2.1.11 Power Distribution Subsystem Checkout

This task will consist of automatic procedures to verify correct operation of the power distribution system prior to subsystems testing. The test will include load evaluation on all circuits of the subsystem, including verification of power switching functions. A portion of the test will include setup for power turn-on of each circuit. Mechanical umbilicals will be mated upon completion of this test.

2.1.12 Preliminary Propulsion Systems Checkout

This task will provide a manually controlled preliminary leak and functional checkout of stage valves.

2.1.13 Signal Conditioning Calibration

This task will be a manual procedure for adjusting the gain on dc amplifiers, 5-volt excitation modules, temperature bridges, and other stage-mounted signal conditioning components. This test will assure that these components are compatible with required telemetry inputs.

2.1.14 Stage DDAS (Digital Data Acquisition System) Checkout

This task will be an automatic end-to-end verification of all channels of the DDAS system. The test will include a remote automatic calibration system test and simulation of and/or ambient readouts from transducers to assure that the DDAS is ready for use. Accuracy and reliability of the system will be demonstrated.

2.1.15 Hardwire Instrumentation Setup and Checkout

This task will be an end-to-end verification of the ground instrumentation system setup and patching. The test will include pressure checks, ambient checks, transducer simulation, voltage verification, and other operations, as applicable, to check system integrity.

2.1.16 Propellant Utilization System Setup, Calibration, and Checkout

This task will include a manual PU (propellant utilization) system calibration. The calibration will consist of LH2 and LOX bridge empty and bridge full calibrations and the PU valve positioner calibration. An electrical calibration of the propellant tanks overfill sensors system will be accomplished during this procedure.

The automatic portion of the PU subsystem checkout is divided into three basic tests:

a. PU system power test will verify that all system power requirements are met.

b. Servo balanced bridge test will verify PU system continuity from the two mass sensors through the summing network.

c. Engine PU valve movement test will verify, the PU system from the slewing network through the servo amplifier and the PU valve positioner.

2.1.17 Range Safety Subsystem Tests

The tests will verify the operational capabilities of the system and will include the following:

a. EBW (exploding bridgewire) and E/I (external/internal) transfer tests.

b. Engine cutoff test

c. Pulse sensor and pulse detector command inhibit test

d. Inflight turn-off command test

e. Propellant dispersion command test

f. Safety and arm device test

g. AGC calibration curves

h. Deviation sensitivity checks

i. RF sensitivity checks

2.1.18 Telemetry System Checkout

This task will activate all five telemetry transmitters to verify center frequency, modulation, calibration step, VSWR, output power, and complete data acquisition system operation.

2.1.19 <u>Exploding Bridge Wire Subsystem Checkout</u>

This task will assure the capability of the EBW subsystems to ignite and jettison the S-IVB ullage rockets. Electronic pulse sensors to simulate EBW detonators and to monitor the output of the system will be installed in place of ordnance devices during the test.

2.1.20 <u>Hydraulic System Fill, Flush, and Bleed Procedure</u>

This task will consist of manual servicing of the hydraulic system and will assure that system fluid cleanliness meets the requirements of MSFC-PROC-166A and that the amount of air in the system is within the allowable limit.

2.1.21 <u>Hydraulic Subsystem Checkout</u>

This task will be an automatic operational checkout of the hydraulic system. The engine will be gimbaled to determine actuator response to commands.

2.1.22 <u>APS Circuitry Checks</u>

This task will be a verification of receipt of command signals routed from the automatic controls system through the IU (Instrument Unit) substitute to the APS electrical interfaces. This will be an automatic procedure using APS simulators.

2.1.23 <u>J-2 Engine Leak and Functional Test</u>

This task will be conducted automatically with periodic holds to accomplish manual functions. The task will verify the integrity of the engine propellant and pneumatic system. The task will also verify proper functioning and timing of engine valves.

2.1.24 <u>Stage Control Pneumatic Leak and Functional Test</u>

This task will be conducted automatically with periodic holds to accomplish the manual functions required to assure the integrity of the pneumatic control system. The proper functional capability of the system will be verified. All pneumatically operated components will be cycled.

2.1.25 Cold Helium System Leak and Functional Test

This task will be a computer-controlled automatic and manual procedure to verify the integrity of the system and assure proper function of system components.

2.1.26 LH2 Tank Pressurization System Leak and Functional Test

This task will be a computer-controlled automatic and manual procedure to verify system integrity and to assure proper functioning of all components.

2.1.27 Propellant Tanks Leak Checks

This task will be an automatic procedure with intermediate holds to accomplish manual leak check operations to verify system integrity at ambient temperature.

2.1.28 Integrated Systems Test

This task is designed as a system checkout of the automatically controlled equipment of the stage, pneumatic console, and propellant sleds in such a manner as to leave the combined system in a ready state for propellant loading and acceptance firing. Stage control pneumatics and GSE pneumatics will be activated to accomplish valve cycling during this test. All electrical systems will be functionally checked during this test.

2.1.29 Simulated Acceptance Firing

This task will use the acceptance firing countdown automatic program and will be conducted as a formal countdown. All functions will occur within the proper framework to simulate the acceptance firing. The test will demonstrate an overall readiness condition to proceed to the propellant loading and acceptance hot firing.

2.2 Preliminary Propellant Loading Test

The purpose of the preliminary propellant loading test will be to verify that the GSE and the stage are compatible during cryogenic operations and to assure that controlling procedures progress to safely monitor and control all necessary functions. The tape program, used for the propellant loading, will be the same as that to be used for the acceptance firing. This test will be conducted approximately one week prior to the acceptance firing. Successful achievement of the test will be a prerequisite for the acceptance firing.

The test will consist of loading LOX and LH2 to the SA-201 vehicle flight requirements. During and after the propellant loading, the following special tests will be conducted in the manual mode (except items d and e):

a. A relief cycle test of the LOX tank vent and relief system will be conducted immediately following LH2 loading.

b. A relief cycle test of the LH2 vent and relief system will be conducted immediately following the completion of LH2 loading.

c. The LOX tank will be overfilled to the point of overfill sensor activation. This test will be conducted following the completion of the relief cycle on the LH2 tank.

d. A critical components cycle test will be conducted immediately prior to initiating the DAC start sequence.

e. An engine start bottle blowdown will be conducted if the test has progressed satisfactorily to this point. The test will be controlled by the acceptance firing tape. The sequence will be allowed to proceed up to the mainstage control signal. The start bottle blowdown will not be a prerequisite for the acceptance firing. The test will be conducted to gain further confidence in the system operation to support mainstage firing.

The terminal countdown sequencing used for STC operations will be sequenced where possible to simulate a KSC launch time table. The terminal countdown sequence will be initiated at approximately T -30 minutes.

During the start bottle blowdown test, the telemetry system will be operated open-loop RF to the GSE ground station. The DDAS system will be transmitted to the TCC (Test Control Center) by coaxial cable. This system is transmitted by cable because of its control-loop function.

The inert APS module pitch and yaw engines will be cycled immediately following cutoff of the start tank blowdown test. Each will be operated in a short duration program to verify the integrity of controls systems from the IU substitute through the stage to the module components.

Should the propellant loading be aborted prior to 100 percent propellant tank filling, mutual DAC-NASA agreement must be reached in order to proceed to acceptance firing. It is planned to conduct a comprehensive data review and to correct data discrepancies prior to acceptance firing.

2.3 Full Duration Acceptance Firing

Countdown for the full duration acceptance firing will be initiated following the evaluation of data from the propellant loading test. As part of the countdown, the integrated system test will be repeated. The test will consist of loading LOX and LH2 to the S-IVB-201 stage flight requirements. Immediately prior to initiating the DAC sequence, a critical component cycle test will be conducted. Terminal countdown will be initiated at approximately T -30 minutes. The terminal countdown, prestart, start, main stage, and shutdown sequencing will simulate a flight sequence as closely as possible within the STC capability. Programmed holds will occur at predetermined times to verify system status and readiness.

The DDAS system will be transmitted to the TCC by coaxial cable. This system is transmitted by cable because of its control-loop function. The PU system will be activated to the closed-loop mode approximately four seconds after main stage indication and will remain in a closed-loop mode throughout the firing duration. The PU system will operate in the PMR mode. The J-2 engine will be gimballed during a portion of engine burning. The gimbal program will include sinusoidal inputs and step commands to the engine pitch and yaw planes. The engine will also be commanded to step in a manner sufficient to verify proper functional operation of hydraulic system compensator. The inert APS module roll engines will each by cycled periodically throughout main stage operation. LH2 tank step pressure command will be issued at approximately 300 seconds of main stage operation. Manual cutoff will be commanded when the propellant level of either tank indicates 1 percent remaining mass. Expected firing duration will be a nominal 460 seconds. The depletion level sensors will also be armed to ensure that propellants are not depleted at engine pump inlets. Immediately following main stage cutoff, the inert APS module pitch and yaw engines will be cycled in a short duration program.

Following safing of systems and reset, propellant residuals will be detanked and systems securing initiated. Within two days following the firing, all hardwire data will be processed and qualified. Immediately following data qualification, system performance evaluation will be initiated. No later than 7 working days following the firing, a test evaluation meeting will be held to accomplish the DAC and NASA test objectives buyoff. One day prior to the meeting, handout material to be presented at the buyoff meeting will be supplied to the NASA Resident Manager's Office, Sacramento Test Center.

2.4 Post-Firing Checkout and Operations

The purposes of the post-firing checkouts and tests will be to assure that the stage and systems are fully operational following the full duration acceptance firing and to verify that no degradation of systems occurred.

All post-firing checkouts will be accomplished with the stage installed in Complex Beta test stand III with the exception of a weight and balance check, which will be accomplished at the VCL (Vehicle Checkout Laboratory) at the STC. The acceptance firing configuration of the stage and associated systems will not be altered until the acceptance firing has been bought off by both agencies. During the interim, those post-firing tasks which may be done in a firing configuration will be accomplished.

2.4.1 Bulkhead Decay Test

This task will demonstrate post-test condition of the bulkhead. The stage bulkhead vacuum system will remain isolated from the stand system for 36 hours after engine cutoff. The first 12 hours will require keeping the tanks pressurized following post-test tank purges. Gas samples will be periodically taken for analysis.

2.4.2 Integrated Systems Test

This task, identical to that in the prefiring operation, will be performed to determine the post-firing condition of the controls and systems.

2.4.3 LH2 Tank Inspection

This task will consist of an interior LH2 tank visual inspection, a growler check of the LH2 side of the common bulkhead, and an ultrasonic check of the tank exterior. The purpose of the test will be to determine the post-loading condition of the LH2 tank insulation and the common bulkhead. Other inspections of basic tank structures will be accomplished. Any discrepancies discovered during these inspections will be evaluated on an individual basis of significance and corrective action.

2.4.4 DDAS Automatic Checkout

This task, identical to that in the prefiring checkout, will be performed to determine the post-firing condition of the system.

2.4.5 Range Safety Subsystem Test

This task will be an end-to-end test of the subsystem to demonstrate that overall functioning has not deteriorated through the engine firing environment.

2.4.6 Telemetry Checkout

This task, a repeat of the prefiring checkout automatic procedures, will be performed to determine the post-firing condition of the system.

2.4.7 EBW Checkout

This task will repeat the end-to-end portions of the prefiring test to demonstrate the system integrity.

2.4.8 Hydraulic Flush Procedure

This task will consist only of the sampling and refill portions of the prefire procedure. If system rework is necessary or if reason exists to suspect system cleanliness, additional portions of the procedure will be accomplished.

2.4.9 Hydraulic System Checkout

This task, identical to prefiring checkout, will be performed to determine the post-firing condition of the system.

2.4.10 Removal of Hardwire Installation and Unique Ground Test Items

This task will return the stage to flight configuration.

2.4.11 Electromagnetic Compatibility

This task will be conducted with special monitoring equipment connected to various stage systems. A simulated flight test will be performed. Measurement of possible source of noise generation and incompatibility will be made. The intent of the test is to qualify and demonstrate system electromagnetic compatibility.

2.4.12 J-2 Engine Leak and Functional Test

This task, a repeat of the prefiring checkout, will be performed to assure system integrity prior to shipment of the stage.

2.4.13 Stage Control Pneumatic Leak and Functional Check

This task, a repeat of the prefiring checkout, will be performed to assure system integrity prior to shipment of the stage.

2.4.14 Cold Helium System Leak and Functional Check

This task, a repeat of the prefiring checkout, will be performed to assure system integrity prior to shipment of the stage.

2.4.15 LH2 Tank Pressurization System Leak and Functional Check

This task, a repeat of the prefiring checkout, will be performed to assure system integrity prior to shipment of the stage.

2.4.16 Propellant Tank Leak Checks

This task, a repeat of the prefiring checkout, will be performed to assure system integrity prior to shipment of the stage.

2.4.17 Aft Skirt and Interstage Thermo-Conditioning and Purge System Checkout

This task will be performed to assure system integrity prior to shipment of the stage.

2.4.18 Integrated Systems Test

This task, a repeat of the first post-firing test, will be performed to demonstrate that all systems are functional prior to the final simulated flight test.

2.4.19 Simulated Flight Test

This task will be performed to demonstrate that the stage is ready for shipment to KSC. The electrical umbilicals will be removed to simulate S-IVB stage liftoff conditions. This will demonstrate that the stage can be controlled through internal power and the IU interface.

2.4.20 Weight and Balance Check

The stage will be removed from the test stand at Complex Beta and transported to the VCL at the STC to perform a weight and balance check. The purpose of this test will be to demonstrate that no significant change has occurred in stage weight and balance. The stage will then be prepared for shipment and transported to the docking area for loading.

2.5 APS Module Confidence Firings at Complex Gamma

The two APS flight modules will be individually confidence fired at Complex Gamma. The confidence firing program will include prefiring, firing, and post-firing operations. The prefiring and post-firing operations are detailed in DAC drawing No. 1B55303, Stage End Item Test Plan, S-IVB-201.

2.5.1 Prefiring Operations

After completion of receiving inspection at the M&A (maintenance and assembly) building, the following electrical and pneumatic checkouts will be performed in preparation for the confidence firing:

a. Continuity and Resistance Checkout

   This test will be performed at the M&A building to establish the electrical continuity and resistance of all instrumentation and control systems.

b. Hardwire Checkout

   The hardwire instrumentation checkout will be performed, after installation of the module in the test cell, to verify the continuity from the module and facilities to the data acquisition system.

c. APS Module Prefire Checkout

   All propulsion systems will be verified for leak tight integrity during this operation. Performance of the valving, pressure switches, regulators, talkbacks, and tank bellows will be functionally verified.

2.5.2 Confidence Firing Operations

Each module will be fully loaded to the "100 percent level" with hypergolic propellants, pressurized with gaseous helium, and fired in accordance with the Countdown Manual. The firing will consist of a series of flight representative pulse firings, accumulating a maximum of 5 seconds burn time on each of the three APS engines. This firing will be conducted at ambient temperature and pressure conditions.

2.5.3 Post-Firing Operations

Upon completion of firing and propellant unloading, each module will be GN2 purged, flushed, and removed from the test cell. The module will be transported to the M&A building where the propellant systems will be disassembled to the module level, for example, propellant control modules and propellant tank assembly. Propellant modules will be flushed using Freon TF and isopropyl alcohol in the oxidizer and fuel systems, respectively. Flushed components will be baked, in a vacuum oven where possible, to reduce Freon and alcohol content to less than 100 PPM. The modules will be reassembled and the following checkouts performed:

a. Continuity and Resistance Checkout

   This checkout will be performed to verify electrical continuity and resistance of all instrumentation and control systems.

b. Leak and Functional Checkout

   All propulsion systems will be verified for leak tight integrity. Performance of the valving, pressure switches, regulators, talkbacks, and tank bellows will be functionally verified.

Following completion of the post-firing operations the modules will be shipped directly to KSC for subsequent installation on the stage.

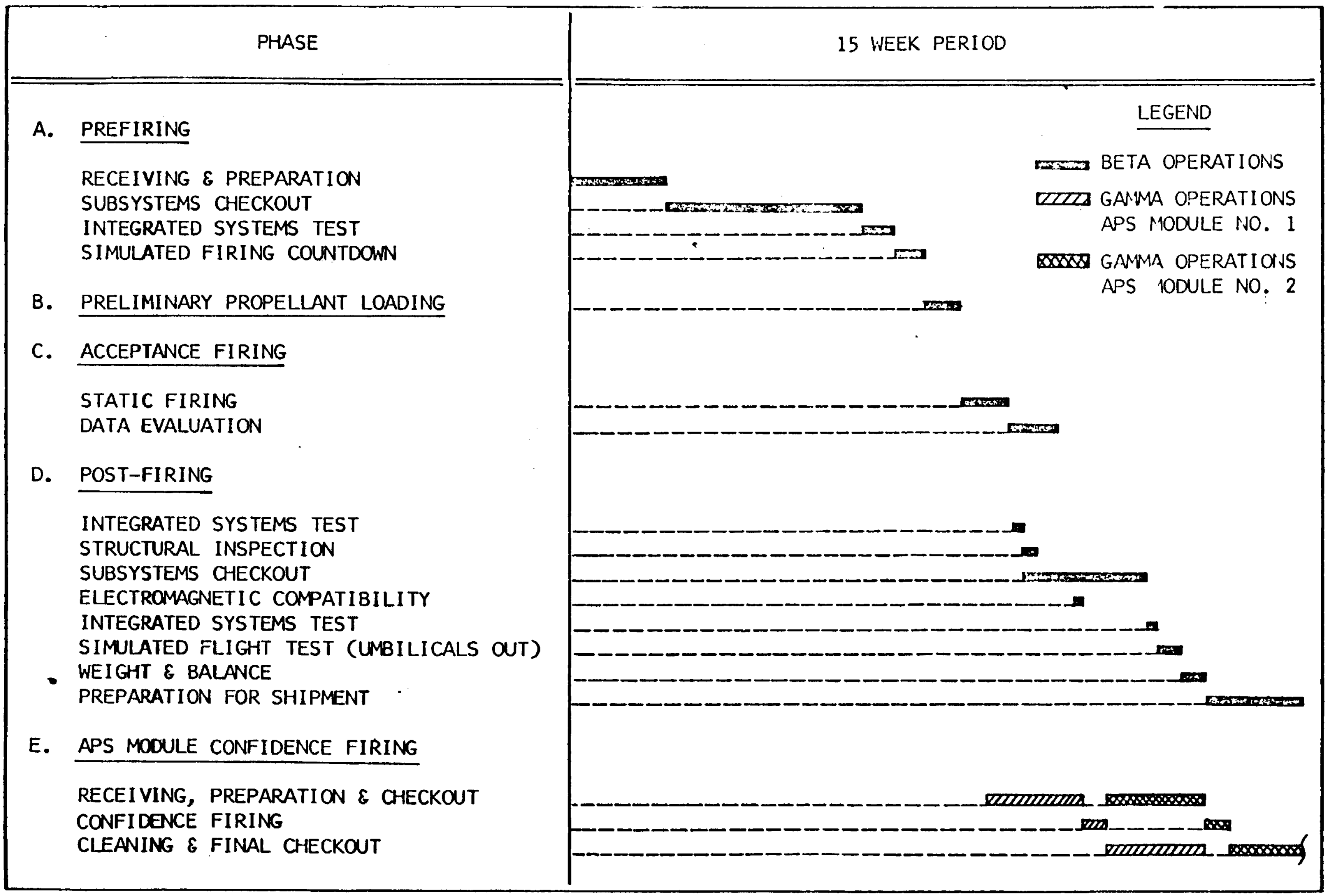


Figure 2-1. S-IVB-201 Stage Acceptance Test Program at STC

SECTION 3

OBJECTIVES

3. OBJECTIVES

The purpose of this section is to present and define the objectives required for the test program. Each test objective is identified by the objective number and title. The objectives are presented in three groups: acceptance objectives, confidence firing objectives, and research and development objectives.

3.1 Acceptance Objectives

Each objective specifies the acceptance criteria required to define the performance necessary to achieve the objective. The S-IVB-201 stage acceptance firing objectives are as follows:

1. Countdown Operations
2. J-2 Engine System Performance
3. Oxidizer System Performance
4. Fuel System Performance
5. Pneumatic Control System Performance
6. Propellant Utilization System Performance
7. Stage Data Acquisition System Performance
8. Electrical Control and Power System Performance
9. Hydraulic System Performance
10. J-2 Engine Gimbal Control Performance
11. Auxiliary Propulsion-Stage System Compatibility Verification
12. Structural Integrity

OBJECTIVE NO: 1 STAGE: S-IVB-201

OBJECTIVE: Countdown Operations

DESIGN BRANCH: Propulsion, Electronics, Structural/Mechanical

DESCRIPTION:

Demonstrate, where possible, that countdown operations can be performed in the sequence and within the time framework allocated for the S-IVB portion of the KSC flight countdown.

ACCEPTANCE CRITERIA:

1. All systems shall demonstrate the propellant and pneumatic flowrates required to meet overall countdown requirements.
2. All purge and environmental control systems shall demonstrate design adequacy and control of prefire purge and environmental conditioning.
3. All stage systems shall respond properly to ground control.
4. The procedures and sequences utilized for the acceptance firing shall demonstrate adequate preparation, control, and monitoring of the stage.
5. The operations that will be applicable to the S-IVB-201 KSC flight countdown shall be executed in the sequence and time specified, except for unique STC operations.

ACCEPTANCE BUYOFF: DAC ______________ NASA ______________

OBJECTIVE NO: 2 STAGE: S-IVB-201

OBJECTIVE: J-2 Engine System Performance

DESIGN BRANCH: Propulsion

DESCRIPTION:

Demonstrate that the J-2 engine exhibits operating characteristics compatible with the stage design requirements and consistent with NAA Rocketdyne Model Specifcation 2158bs.

An analysis of engine performance will be made to verify the engine exhibits essentially normal transient and steady-state operation.

ACCEPTANCE CRITERIA:

1. Thrust Chamber Pressure:

   a. Shall reach 90 percent chamber pressure psia within 6.0 seconds after engine start command.

   b. Shall not, during the start transient, exceed 103 percent of steady state value.

   c. Shall exhibit a smooth and rapid cutoff, and the duration from cutoff signal to 5 percent chamber pressure shall be approximately 0.5 seconds.

2. Engine Fuel and Oxidizer Systems:

   a. Shall verify the achievement of adequate childown.

   b. Shall exhibit essentially nominal pressures and temperatures as established by Rocketdyne Model Specification 2158bs.

   c. Shall verify proper functioning during prestart, start, steady state, and cutoff.

NOTE

Propellant inlet conditions will normally reflect stage pressurization and supply system performance and will be demonstrated under objectives for these systems.

3. Engine Subsystems

   a. Shall verify satisfactory performance of the gas generator and turbopumps.

   b. Shall verify that the start system, control pneumatic system, and the LH2 tank pressurization supply system exhibit satisfactory performance

ACCEPTANCE BUYOFF: DAC ____________ NASA ____________

OBJECTIVE NO: 3 STAGE: S-IVB-201

OBJECTIVE: Oxidizer System Performance

DESIGN BRANCH: Propulsion

DESCRIPTION:

Demonstrate that LOX is supplied to the engine inlet within the established operating limits through the proper functioning of the LOX tank pressurization system and supply system. Proper transition from ground prepressure control to flight control will also be demonstrated.

ACCEPTANCE CRITERIA:

1. LOX Pump Inlet Conditions:

   a. Shall demonstrate the required pressures and temperatures to achieve satisfactory engine start.

   b. Shall be maintained within the steady state operating limits established by Rocketdyne Model Specification 2158bs.

2. LOX Tank Ullage

   Shall be prepressurized to 37 to 40 psia, and maintained between 37 to 40 psia during steady state operation.

3. Cold Helium Supply:

   Shall be sufficient to maintain ullage pressures noted for the prescribed operating time.

ACCEPTANCE BUYOFF: DAC __________ NASA __________

OBJECTIVE NO: 4

STAGE: S-IVB-201

OBJECTIVE: Fuel System Performance

DESIGN BRANCH: Propulsion

DESCRIPTION:

Demonstrate that LH2 is supplied to the engine inlet within established operating limits through the proper functioning of the LH2 tank pressurization system and supply system.

Demonstrate proper transition from ground prepressure control to flight control.

ACCEPTANCE CRITERIA:

1. LH2 Pump Inlet Conditions:
   a. Shall demonstrate the required pressures and temperatures to achieve satisfactory engine start.
   b. Shall be maintained within the steady state operating limits established by Rocketdyne Model Specification 2158bs.
2. LH2 Tank Ullage:
   a. Shall be prepressurized to 32 to 37 psia, and be maintained between 28 to 31 psia during steady state operation prior to the step pressure command.
   b. Shall be sufficient to maintain minimum engine pump inlet conditions, from step pressure command to cutoff.

ACCEPTANCE BUYOFF: DAC________________ NASA________________

OBJECTIVE NO: 5

STAGE: S-IVB-201

OBJECTIVE: Pneumatic Control System Performance

DESIGN BRANCH: Propulsion

DESCRIPTION:

Demonstrate that the pneumatic control supply furnishes sufficient helium at the correct pressures to provide adequate pneumatic valve control and system purges.

ACCEPTANCE CRITERIA:

1. Control helium system must maintain pressure at 440 to 550 psia.
2. Storage bottle helium pressure shall remain above 440 psia for the duration of the acceptance firing.
3. The engine turbopump purge pressure shall be maintained between 100 and 130 psia at the customer connect panel. The LOX chilldown pump purge pressure shall remain between 49 and 53 psia.
4. Demonstrate satisfactory control of the pneumatically actuated valves.

ACCEPTANCE BUYOFF: DAC __________ NASA __________

OBJECTIVE NO: 6 STAGE: S-IVB-201

OBJECTIVE: Propellant Utilization System Performance

DESIGN BRANCH: Propellant Utilization Panel

DESCRIPTION:

Demonstrate that the PU (propellant utilization) system can control the loading and consumption of propellants within the design requirements of the stage and engine as applicable to acceptance firing.

Final detailed evaluation of the overall PU system performance will be accomplished at the Space System Center through the use of computer programs.

ACCEPTANCE CRITERIA:

1. The final loaded indicated mass in each tank shall be within ±3.0 percent of the desired loaded mass. The calibration of the indicated loaded mass data will be basically derived from an analytic determination of the tank volume versus height relationship and further refined by the results of the preliminary propellant loading test.

2. Establish that sufficient data have been gathered to enable subsequent recalibration of the PU electronics assembly to yield loaded mass accuracies within ±1.0 percent (RSS) of the actual loaded mass based on a three sigma probability. This recalibration will be based upon mass consumption values obtained using the flow integral method.

3. The control of propellant consumption shall be termed acceptable based upon the following criteria:

    a. An acceptable correlation shall be evident in the PU valve response as commanded by the PU error signal.

    b. The validity of the PU error signal shall be determined from final detailed analysis of the overall PU system performance.

ACCEPTANCE BUYOFF: DAC________________ NASA________________

OBJECTIVE NO: 7 STAGE: S-IVB-201

OBJECTIVE: Stage Data Acquisition System Performance

DESIGN BRANCH: Electronics

DESCRIPTION:

Demonstrate that the data acquisition system is operating properly and is capable of performing assigned functions. All measured parameters will be checked to insure that they are being received correctly. Selected measurements will be checked for accuracy. The electromagnetic compatibility of the telemetry system with other stage hardware, in respect to conducted and radiated interference, also will be evaluated.

ACCEPTANCE CRITERIA:

1. Subsystem Operation

   The performance of telemetry components will be acceptable if:

   a. Upon command, an RF signal of adequate strength and deviation is received at the ground station.

   b. The subcarrier signals exhibit the required amplitude and deviation.

   c. The pulse amplitude and pulse code modulation signals are of nominal amplitude and timing accuracy.

   d. The onboard tape recorder operates properly on command and records and plays back usable data.

2. Parameter Measurements

   Information reduced from a specific channel shall correspond to hardwire data or to its estimated amplitude and frequency, or be proven to be correct and new criteria established.

3. Compatibility

   Compatibility of the telemetry and other hardware in proximity or deriving power from a common source will be evaluated by an examination of the telemetry data. Poor signal-to-noise ratio or the appearance of extraneous switching transients, or "hash" on the data will be cause for corrective action.

ACCEPTANCE BUYOFF: DAC ________________ NASA ________________

OBJECTIVE NO: 8 STAGE: S-IVB-201

OBJECTIVE: Electrical Control and Power System Performance

DESIGN BRANCH: Electronics

DESCRIPTION:

Demonstrate the proper operation of the following during firing:

GSE/Stage interface; S-IVB sequence functions routed through switch selector and sequencer; forward and aft control distributors; forward, aft 28V and aft 56V power distributors; control pressure switches on engine and pressurization systems; stage electrical systems operation within the design load profile; and proper transfer of power from the external to the internal source.

Demonstrate that battery currents, voltages, temperatures; chilldown inverter frequency, voltages, temperatures; 5 volt excitation module frequency, and voltages; static inverter-converter frequency, voltages, and temperatures remain within acceptable limits during acceptance firing.

ACCEPTANCE CRITERIA:

1. GSE/Stage Interface

   Proper mating of the umbilical shall be demonstrated by utilizing the "connectors mated" measurements. Integrity of the umbilical interlock and safety indications shall be demonstrated.

2. Control Distributors

   Proper operation of the control distributors shall be demonstrated by monitoring the arrival at GSE of all expected indications and the receipt in the stage of all GSE originated commands.

3. Sequence Functions

   Proper operation of the switch selector and sequencer shall be demonstrated by following an anticipated launch-flight sequence of events and by obtaining correct response of stage elements.

4. Power Distribution Assemblies

   Proper operation of the motor-driven switches shall be demonstrated.

5. Control Pressure Switches

   Proper operation of the control pressure switches shall be verified by analysis of engine and pressurization systems performance.

6. External/Internal Switches

   Proper operation of the external/internal (E/I) switches will be verified by analysis of E/I talkback indications.

OBJECTIVE NO: 8 STAGE: S-IVB-201

Page 2

ACCEPTANCE CRITERIA: (Continued)

7. The following components shall demonstrate the listed performance:

Forward Battery No. 1	
Voltage:	28 ±2vdc
Current:	Maximum 40 amps
Temperature:	80 ±10°F
Forward Battery No. 2	
Voltage:	28 ±2vdc
Current:	Maximum 7 amps
Temperature:	80 ±10°F
Aft Battery No. 1	
Voltage:	28 ±2vdc
Current:	Maximum 120 amps
Temperature:	80 ±10°F
Aft Battery No. 2	
Voltage:	56 ±4vdc
Current:	Maximum 135 amps
Temperature:	80 ±10°F
Chilldown Inverters:	Both LOX and LH2
Voltage:	0 to 60 volts per phase
Frequency:	400 ±10 cps
Temperature:	-100° to +375°F
5 Volt Excitation Module	
Voltage:	5.0 ±0.5 vdc
Frequency:	2000 ±200 cps
Static Inverter-Converter	
Voltage	115 ±3.45v at 400 ±6 cps 5.0 ±0.5vdc 21.0 (+1.5 -1.0) vdc

ACCEPTANCE BUYOFF: DAC____________________ NASA ____________________

OBJECTIVE NO: 9 STAGE: S-IVB-201

OBJECTIVE: Hydraulic System Performance

DESIGN BRANCH: Structural/Mechanical

DESCRIPTION:

Demonstrate that the pressure and temperature levels of the hydraulic system are within acceptable limits.

ACCEPTANCE CRITERIA:

1. Accumulator GN2 Pressure and Temperature.

   a. Prior to auxiliary hydraulic pump start the accumulator GN2 pressure shall be greater than 1900 psia.

   b. The GN2 pressure shall exceed 3500 psia within 60 seconds after auxiliary pump start and during the acceptance firing shall be 3650 (+50 -150) psia. (During engine gimbaling and the engine start transient, short term pressure surges to 3800 psia maximum and 3400 psia minimum are acceptable.)

   c. The GN2 temperature must exceed the minimum of 0°F before system pressurization.

   d. After the acceptance firing and with the auxiliary pump inoperative the GN2 mass shall be between 1.70 and 2.15 calculated by the formula.

$$\text{GN2 Mass (lb)} = \frac{\text{GN2 Pressure (psia)}}{\text{GN2 Temperature } (^{\circ}\text{R})} \times 0.4326$$

2. Hydraulic System Pressure and Temperature

   a. Following auxiliary pump start and full pressurization of the accumulator GN2, the minimum system pressure shall be 3500 psia.

   b. The system pressure during the acceptance firing shall be 3650 (+50 -150) psia. (During engine gimbaling and engine start transient short term pressure surges to 3800 psia maximum and 3400 psia minimum are acceptable.)

   c. The temperature of the hydraulic pump inlet oil shall not be below -10°F prior to auxiliary pump start and shall not exceed 275°F during the acceptance firing.

3. Reservoir Oil Pressure

   a. The reservoir oil pressure prior to auxiliary pump start shall be a minimum of 55 psia. During pump steady state operation the minimum pressure shall be 155 psia.

   b. During the firing the reservoir oil pressure shall nominally be 170 psia and shall not exceed 210 psia.

ACCEPTANCE BUYOFF: DAC ______________ NASA ______________

OBJECTIVE NO: 10 STAGE: S-IVB-201

OBJECTIVE: J-2 Engine Gimbal Control Performance

DESIGN BRANCH: Structural/Mechanical, Flight Dynamics & Control

DESCRIPTION:

Demonstrate that the servo system is capable of gimbaling the engine in response to servo valve input current commands in a satisfactory manner.

ACCEPTANCE CRITERIA:

1. The differential pressure feedback network of the hydraulic engine positioning servo system must operate satisfactorily with respect to both the frequency response and engine step command tests.
2. The engine slew rate shall reach a minimum of eight degrees per second (1.66 inches per second as measured at the actuator feedback potentiometer) in response to a two degree step command.
3. Actuator piston position versus command phase lag at 1 cps must be within acceptable tolerances.

ACCEPTANCE BUYOFF: DAC____________________ NASA____________________

OBJECTIVE NO: 11 STAGE: S-IVB-201

OBJECTIVE: Auxiliary Propulsion-Stage System Compatibility Verification

DESIGN BRANCH: Propulsion, Electronics, Flight Dynamics and Control

DESCRIPTION:

Demonstrate that the auxiliary propulsion system responds to commands from the instrument unit substitute.

ACCEPTANCE CRITERIA:

The APS module and the APS simulator functioning as an attitude control system shall demonstrate execution of flight attitude sequencing as commanded by the IU substitute.

1. The module shall exhibit system performance including response times consistent with module design requirements and limitations imposed by use of simulated propellants.

2. Verify the control discrimination ability of the APS actuation control modules by use of the telemetry talkbacks from the APS simulator and inert APS module.

ACCEPTANCE BUYOFF: DAC ________________ NASA ________________

OBJECTIVE NO: 12 STAGE: S-IVB-201

OBJECTIVE: Structural Integrity

DESIGN BRANCH: Strength, Aero/Thermodynamics, Structural/Mechanical

DESCRIPTION:

Demonstrate the structural integrity of the stage.

ACCEPTANCE CRITERIA:

To comply with this objective, the following items must be successfully completed.

1. Common bulkhead pressure shall be monitored and gas samples taken during cryogenic propellant loading, acceptance firing, prefiring and postfiring checkouts to evaluate bulkhead leak integrity.

2. The forward thermo-conditioning system shall be considered acceptable after performing a system leak check and ΔP test to prove that no structural damage has occurred to the cold plates and manifold during the acceptance firing.

3. Perform the following inspections of the stage after completion of the acceptance firing test:

    a. Visually inspect the inside of the LH2 tank to assure the integrity of the insulation.

    b. Perform a growler check on the LH2 side of the common bulkhead.

    c. Perform an external ultrasonic check of the LH2 tank cylindrical section and forward dome to be sure the insulation has not debonded.

    d. Perform a visual inspection of the thrust structure, LOX tank aft dome, LH2 tank aft dome, aft skirt, LH2 tank cylindrical section, LH2 tank forward dome, forward skirt, and plumbing and wiring supports to assure that structural degradation has not occurred.

    e. Perform an airflow test of the aft thermo-conditioning and purge system to check the distribution system orifice areas and leakage areas for integrity.

Possible structural discrepancies which cannot be defined at this time may occur during the above inspections. Any such discrepancy will be evaluated individually

ACCEPTANCE BUYOFF: DAC__________ NASA __________

3.2 Confidence Firing Objectives

The confidence firing objectives are contained in this subsection. Each objective specifies the confidence firing criteria required to define the performance necessary to achieve the objective. The S-IVB-201 APS module confidence firing objectives are as follows:

C-1. Auxiliary Propulsion System Module No. 1 Performance

C-2. Auxiliary Propulsion System Module No. 2 Performance

OBJECTIVE NO: C-1 STAGE: S-IVB-201

OBJECTIVE: Auxiliary Propulsion System Module No. 1 Performance

DESIGN BRANCH: Propulsion

DESCRIPTION:

Verify that the auxiliary propulsion system responds properly to ground loading and flight type firing commands. Establish from confidence firing data that the module exhibits operating characteristics compatible with module design requirements.

CONFIDENCE FIRING CRITERIA:

1. The response time of each injector valve shall be within the design limits set forth in TRW Model Specifications No. 03-10060, Revision C.
2. Measured steady state thrust chamber pressure of each engine shall be 100 ±5 psia (sea level).
3. Calculated steady state thrust of each engine shall be 145 ±10 lbs (corrected to vacuum conditions).
4. Determine the minimum impulse bit to be 7.5 ±1 lb second with all propellant valves operating for 65 milliseconds. The pulse width is defined as that time from first indication of thrust chamber pressure rise to dropout.
5. Demonstrate the oxidizer and fuel propellant tanks can be loaded to 100 percent.
6. Verify oxidizer and fuel tank pressures 200 ±5 psia.
7. Verify helium regulated outlet pressure 200 ±5 psia.
8. Verify helium sphere pressure 3000 ±200 psia (loaded).

CONFIDENCE FIRING BUYOFF: DAC ______ NASA ______

OBJECTIVE NO: C-2 STAGE: S-IVB-201

OBJECTIVE: Auxiliary Propulsion System Module No. 2 Performance

DESIGN BRANCH: Propulsion

DESCRIPTION:

Verify that the auxiliary propulsion system responds properly to ground loading and flight type firing commands. Establish from confidence firing data that the module exhibits operating characteristics compatible with module design requirements.

CONFIDENCE FIRING CRITERIA:

1. The response time of each injector valve shall be within the design limits set forth in TRW Model Specifications No. 03-10060, Revision C.
2. Measured steady state thrust chamber pressure of each engine shall be 100 ±5 psia (sea level).
3. Calculated steady state thrust of each engine shall be 145 ±10 lbs (corrected to vacuum conditions).
4. Determine the minimum impulse bit to be 7.5 ±1 lb second with all propellant valves operating for 65 milliseconds. The pulse width is defined as that time from first indication of thrust chamber pressure rise to dropout.
5. Demonstrate the oxidizer and fuel propellant tanks can be loaded to 100 percent.
6. Verify oxidizer and fuel tank pressures 200 ±5 psia.
7. Verify helium regulated outlet pressure 200 ±5 psia.
8. Verify helium sphere pressure 3000 ±200 psia (loaded).

CONFIDENCE FIRING BUYOFF: DAC__________ NASA __________

3.3 Research and Development Objectives

The research and development objectives for the S-IVB-201 stage acceptance firing are contained in this subsection and are as follows:

R-1. Acceptance Firing Thermodynamics

R-2. Acceptance Firing Vibrations and Acoustics

OBJECTIVE NO: R-1 STAGE: S-IVB-201

OBJECTIVE: Acceptance Firing Thermodynamics

DESIGN BRANCH: Aero/Thermodynamics

DESCRIPTION:

Determine propellant heating and the thermodynamic environment and performance of components and structures of the S-IVB-201 stage when subjected to cryogenic propellant loading and acceptance firing.

Temperature, pressure, and propellant level data are to be used for determining the magnitude of propellant heating, the effectiveness of fuel tank internal insulation, and the effects of J-2 engine exhaust on structures and components.

STAGE: S-IVB-201

OBJECTIVE NO: R-2

OBJECTIVE: Acceptance Firing Vibrations and Acoustics

DESIGN BRANCH: Acoustics and Structural Dynamics

DESCRIPTION:

Determine the vibration input or response of propulsion subsystems components, flight control subsystem components, electronic equipment, and primary stage structure. Determine the acoustical environment inside and outside forward skirt.

Vibration

1. Evaluate the turbopump vibration environment.
2. Determine the vibration environment of the hydraulic actuator servo valves and vibration input to the thrust structure from the engine.
3. Determine the vibration input to and response of electronic equipment panels in the forward and aft skirts.
4. Determine the combustion chamber dome vibration environment.
5. Determine the vibration input to thrust structure and response of field splice ring frame.
6. Determine the vibration input to the attitude control module and to the cold helium sphere in the LH2 tank.

Acoustics

Determine the internal and external sound pressure level on the forward skirt.

SECTION 4

TEST CONFIGURATION

4. TEST CONFIGURATION

This section describes the acceptance firing configuration of the stage at Complex Beta and the configuration of the two auxiliary propulsion system modules that will be tested at Complex Gamma. The overall stage configuration is presented in detail in DAC drawing number 1B55303, S-IVB-201 Stage End-Item Test Plan.

4.1 Propulsion System

4.1.1 Propulsion System Description

The propulsion system consists essentially of six subsystems; the J-2 engine, LOX tank, LH2 tank, LOX tank pressurization, LH2 tank pressurization, and the pneumatic control. These subsystems, described below, are shown in figure 4-1 without the J-2 engine.

a. The J-2 engine, gimbal mounted and capable of 200,000 lb vacuum thrust, uses LOX and LH2 propellants. Major components of the J-2 engine are: thrust chamber, LH2 turbopump, LOX turbopump, propellant utilization valve, spark ignition system, electrical control package, instrumentation for monitoring engine parameters, turbine start sphere, pneumatic system, gas generator, heat exchanger, and control valves.

b. LOX and LH2 tank subsystems accept, store, and supply propellants to the J-2 engine. In addition to these functions, the tank subsystems provide cryogenically immersed chilldown pumps to precondition the J-2 turbomachinery. The side walls and domes of the LH2 tank are internally insulated for minimization of heat input from the stage skin. Thermo isolation between the tanks is provided by the common bulkhead.

c. LOX and LH2 tank pressurization modules control prepressurization during the ground fill operation and pressurization during J-2 engine operation. Helium for the LOX tank pressurization supply is loaded from a ground source and stored in "cold" helium bottles in the LH2 tank. The LOX tank pressurization module provides regulation of the amount of cold helium to be bypassed through the J-2 engine heat exchanger. The hydrogen pressurization module provides regulation of engine bleed hydrogen by use of demand and step control valves.

d. The pneumatic control subsystem uses helium to operate LOX and LH2 relief valves, the fill and drain valves, the engine feed system valves, and the J-2 engine start tank dump valve. Helium is also provided to purge the J-2 engine propellant pump cavity seals and the LOX chilldown pump motor. Helium is stored in a sphere on the thrust structure.

4.1.2 Acceptance Firing Deviations

Configuration deviations for acceptance firing are as follows:

a. LOX and LH2 tank vents and GH2 bleeds will be connected to the facility burning and venting systems.

b. Stage portions of the pneumatic and propellant umbilical quick-disconnects will be removed and will be replaced by hardline.

c. A converging diffuser will be attached at the engine thrust chamber exit to reduce nozzle area ratio. The diffuser is required to reduce the probability of jet separation induced side loads during PU excursions. Cooling will be provided by GN2 until engine start, and water will be used thereafter. The diffuser will be removed prior to shipment of the stage.

d. Model DSV-4B-618, Unlatch Restrainer Links, will be installed to restrain the engine during start transient side loads. The engine portion of the restrainer system will be removed prior to shipment of the stage.

4.2 Auxiliary Propulsion System

4.2.1 Auxiliary Propulsion System Description

The flight stage has two APS modules. Each module (figure 4-2) has three 150-lb thrust attitude control engines, positive expulsion propellant tanks, engine propellant manifolds, a helium sphere, and helium and propellant valves. The engines use nitrogen tetroxide for oxidizer and monomethylhydrazine for fuel.

4.2.2 Stage Acceptance Firing Deviations

Configuration deviations for stage acceptance firing at Complex Beta are as follows:

a. Model DSV-4B-188, APS Simulator, will be connected to position no. 1 to receive commands and to close the control circuitry.

b. A flight equivalent developmental APS module will be in position no. 2. Propellant tanks will contain inert fluids.

4.2.3 APS Confidence Test Module Configuration

The two APS modules to be tested at Complex Gamma will be of flight configurations and will be as described in paragraph 4.2.1. Configuration deviations for each module firing are as follows:

a. APS engine nozzle aspirators will be installed on each of the engines to prevent after burning.

b. Two pneumatic system pressure ports will be installed and connected to a module monitor panel to allow on-stand monitoring of critical system pressure during checkout and set-up. Ports will be removed prior to shipment.

c. Propellant and pneumatic interfaces between the module and GSE (Ground Support Equipment) will be maintained during the firing for safety reasons.

d. Module commands will be provided by IU simulation from the Model DSV-4B-556, APS Module Control Console.

e. All applicable module instrumentation will be hardwired to the data acquisition system.

4.3 Electrical Power System

4.3.1 Electrical Power System Description

The electrical power system (figures 4-3 and 4-4) consists of two forward and two aft batteries, two chilldown inverters, two 5 vdc excitation modules, seventeen 20 v excitation modules, and a static inverter-converter.

a. Batteries

Forward battery no. 1 provides dc power for the telemetry transmitters, recorders, transducers, switch selector, propellant dispersal system no. 1, checkout measurement group, 5 vdc excitation modules.

Forward battery no. 2 provides dc power for the PU (propellant utilization) system, static inverter-converter, and propellant dispersal system no. 2.

Aft battery no. 1 provides dc power for the J-2 engine, sequencer, pressure switches, level sensors, LH2 and LOX tank fill and drain valves, APS modules no. 1 and no. 2, ullage rocket motor ignition and jettison.

Aft battery no. 2 provides dc power for the LH2 and LOX chilldown inverters and for the auxiliary hydraulic pump motor.

b. Chilldown Inverter

The chilldown inverter is a transistorized power conversion device which transforms 56 vdc to a 56v, 3 phase, quasi-square wave at 400 cps.

c. 5V Excitation Module

The 5 vdc excitation module is a transistorized power conversion device which transforms the 28 vdc to +5 vdc, -20 vdc and four 10v peak-to-peak square waves at 2,000 cps.

d. 20 V Excitation Module

The 20 vdc excitation module is a transistorized power conversion device used in the instrumentation signal conditioning panels.

e. Static Inverter-Converter

The static inverter-converter provides proper voltages to the PU electronics assembly.

4.3.2 Acceptance Firing Deviations

Configuration deviations for acceptance firing are as follows:

a. The electrical umbilicals will remain connected throughout the acceptance firing duration. The electrical umbilical will only be removed for the postfiring simulated flight test.

b. Facility batteries will be used to supply stage power during the propellant loading and start bottle blowdown test. Flight type batteries will be used for the acceptance firing.

4.4 Electrical Control System

4.4.1 Electrical Control System Description

The stage electrical control system (figure 4-5) consists of the units described below:

a. The forward control distribution assembly distributes all stage control commands and talkback signals to the three forward command umbilical connectors.

b. The forward power distribution assembly distributes power from forward batteries no. 1 and no. 2. It contains the E/I (External/ Internal) power transfer switch that switches from ground power to stage power immediately prior to launch.

c. The aft control distribution assembly distributes all stage control commands and talkback signals to four aft command umbilical connectors.

d. The 56v aft power distribution assembly distributes power from the 56v aft battery to the auxiliary hydraulic pump motor and chilldown inverters.

e. The 28v aft power distribution assembly distributes power from the 28v aft battery no. 1 and GSE talkback bus to the engine, APS, sequencer, pressure switches, EBW pulse sensors, and position indication switches; it is also a distribution point for circuitry in the aft area.

f. The switch selector consists of a group of low power transistor switches used as relay drivers, controlled by binary coded signals received from the IU computer.

g. The sequencer provides logic circuitry for control and operation of the stage subsystems during flight.

4.4.2 Acceptance Firing Deviations

Configuration deviations for acceptance firing are as follows:

a. The electrical umbilical will remain connected throughout the acceptance firing. The electrical umbilicals will only be removed during the postfiring simulated flight test.

b. The IU and S-IB stage electrical interfaces will be simulated by GSE.

c. The switch selector will be of non-flight type.

d. All controls signals will be routed through the umbilicals and the IU and S-IB stage substitutes.

4.5 Engine Hydraulic System

4.5.1 Engine Hydraulic System Description

The engine hydraulic system (figure 4-6) is an independent, closed-loop system that controls the engine's thrust vector by converting electrical guidance signals into mechanical translations of the gimbal-mounted J-2 engine. Major subassemblies are the engine driven hydraulic pump, auxiliary hydraulic pump, accumulator-reservoir, and servo-actuators. These, with associated valves, filters, tubing, flexible hoses, and an air supply for the auxiliary hydraulic pump, comprise the hydraulic system.

The auxiliary hydraulic pump and the accumulator reservoir are mounted on the stage thrust structure; the engine-driven pump is mounted on, and is driven by the engine LOX pump; the servo-actuators are attached to the engine and the thrust structure.

4.5.2 Acceptance Firing Deviations

The hydraulic system configuration for the acceptance firing will be the same as that for the flight.

4.6 Propellant Utilization System

4.6.1 Propellant Utilization System Description

The PU (propellant utilization) system, figure 4-7, controls the engine mixture ratio during engine firing to achieve optimum consumption of propellants and counteracts deviations of propellant flow rates from nominal. During propellant loading the PU system provides indicated mass signals to the computer to control propellant loadings.

The PU system consists of four major components: LOX mass sensor, LH2 mass sensor, PU electronic assembly, and the engine mixture ratio valve positioner.

4.6.2 Acceptance Firing Deviations

The PU system configuration for the acceptance firing will be the same as that for the flight with the exception that the fast fill sensors will be used in the indicating mode only.

4.7 Data Acquisition System

4.7.1 Data Acquisition System Description

The data acquisition system (figure 4-8) acquires, conditions, and transmits data to evaluate stage performance and environment during acceptance firing. This system consists of the instrumentation and telemetry subsystems: the instrumentation subsystem acquires and conditions the data and the telemetry subsystem transmits it.

a. Instrumentation Subsystem

The instrumentation subsystem gathers data with transducers and conditions it, when necessary, by amplification or attenuation.

b. Telemetry Subsystem

The telemetry subsystem consists of the following major elements: PAM/FM/FM system, PCM/FM system, FM/FM system, SS/FM system, RF system, antenna system, flight tape recorder assembly, and calibration system.

4.7.2 Acceptance Firing Deviations

Configuration deviations for acceptance firing are as follows:

a. Hardwired measurements will be provided as specified in DAC drawing No. 1B55758, Instrumentation Program - Support Measurements List, Acceptance Test Firing, S-IVB-201.

b. Flight measurements, disconnected from the telemetry system for hardwire usage, will be simulated.

c. The central decoder will be disconnected.

4.8 Propellant Dispersal System

4.8.1 Propellant Dispersal System Description

The propellant dispersal system, shown in figure 4-9, consists of two subsystems: no. 1 and no. 2. Each subsystem has a folded sleeve antenna, a propellant dispersal receiver, a controller assembly, and EBW firing unit, and an EBW detonator. One safe and arm device, common to both subsystems, connects them to the detonating cord.

The power divider connected to the antennas provides a means of applying a closed-loop checkout signal to the propellant dispersal receivers from ground support equipment.

Two outputs of a directional power divider are applied separately to the two propellant dispersal receivers.

4.8.2 Acceptance Firing Deviations

Configuration deviations for acceptance firing are as follows:

a. Safe and arm device will be inert.

b. EBW detonators will be simulated by EBW pulse sensors.

c. Explosive cords will not be installed.

d. Propellant dispersal system will not be interrogated during acceptance firing.

e. Propellant dispersal receiver no. 1 will be disconnected.

4.9 Aft Skirt and Aft Interstage Thermo-Conditioning and Purge System

4.9.1 Thermo-Conditioning and Purge System Description

The aft skirt and aft interstage thermo-conditioning and purge system consists of a temperature-controlled air/GN2 distribution system. During prefiring and engine firing periods this system thermal-conditions the atmosphere around the electrical equipment on the aft skirt and purges the skirt and interstage area of combustible gases. In the flight configuration the purge stops at liftoff.

Air/GN2 from a ground blower and heater system enters the skirt manifold through the aft skirt umbilical. This manifold, formed by the stage tanks, aft skirt, ring frame, and flexible membrane, directs the flow into the aft interstage through fixed orifices in the ring frame. A duct from the skirt manifold directs air/GN2 to the thrust structure manifold for distribution to the thrust structure; from the thrust structure inlet duct some flow is directed to a shroud that covers the hydraulic accumulator-reservoir. Additional air/GN2 is directed from the skirt manifold to each APS module and is exhausted into the aft interstage.

4.9.2 Acceptance Firing Deviations

The configuration deviation for acceptance firing is that the stage will be mounted on the model DSV-4B-540, dummy aft interstage.

4.10 Forward Environmental Control System

4.10.1 Forward Environmental Control System Description

a. Forward Purge System - The forward skirt area is purged with GN2 to minimize fire hazards when propellants are on board. For stage acceptance firing, GN2 from a remote environmental control system enters the stage through the forward skirt protective firing cover. In the flight configuration the purge gas enters through the IU umbilical and stops at liftoff.

b. Forward Thermo-Conditioning System - Electrical equipment in the forward skirt area is thermally conditioned by a heat transfer system which uses a fluid circulating through thermal conditioning panels (cold plates) to transfer heat. The electrical equipment is attached to the panels and heat is dissipated from the point of attachment to the fluid by conduction. In the flight configuration the fluid is supplied from the instrument unit.

4.10.2 Acceptance Firing Deviations

Configuration deviations for acceptance firing are as follows:

a. The forward skirt purge system will be operated at all times when a GH2 atmosphere exists in the LH2 tank.

b. A flame resistant protective firing cover incorporating a relief valve will be installed to enclose the forward area.

c. Fluid for the heat transfer system will be supplied from a ground servicer, model DSV-4B-359 forward skirt thermoconditioning unit; this system will be operated at all times when vehicle power is on.

4.11 Complex Beta Facility and Support Equipment

The facility and support equipment will consist of test stand III and associated facilities, the test control center, facility equipment, ground support equipment, and instrumentation. Facility and ground support equipment are listed in appendix 4.

4.12 Complex Gamma Facility and Support Equipment

The facility and support equipment will consist of the test structure, test control center, instrumentation center, propellant storage areas, facility equipment, and ground support equipment. The Complex Gamma ground support equipment is listed in appendix 5, in groups according to location of the equipment during testing.

4.13 Other Changes

Additional changes that will be made for the firing at Complex Beta are as follows:

a. The resistance-wire fire detection system will be installed in critical areas of the stage, GSE, and facilities.

b. GH2 leak detectors will be installed in critical areas of stage, GSE, and facilities.

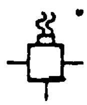
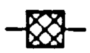
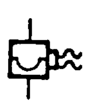
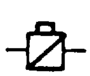
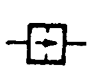
c. The S-IVB stage mounted rate gyros and accelerometers required in support of the flight guidance system will not be installed during the acceptance program.

d. Live ordnance for the propellant dispersal, retro rocket, and ullage rocket systems will not be installed at any time of the acceptance program.

e. An auxiliary pressurization system for both the LOX and LH2 tanks will be installed from a GSE helium source. This system will be used to supplement the normal prepressurization and pressurization systems if required.

Table 4-1

SCHEMATIC SYMBOLS

	Coupling half, quick disconnect (with check valve)
	Coupling half, quick disconnect (without check valve)
	Electro-pneumatic (pilot operated, solenoid)
	Filter, strainer or purifier
	Flow regulator (pneumatically operated)
	Line capped
	Motor
	Orifice
	Regulator, pressure, dome, with reference pressure
	Regulator, pressure, hand operated
	Switch, pressure, with electrical output
	Switch, step pressure
	Valve, butterfly
	Valve, check

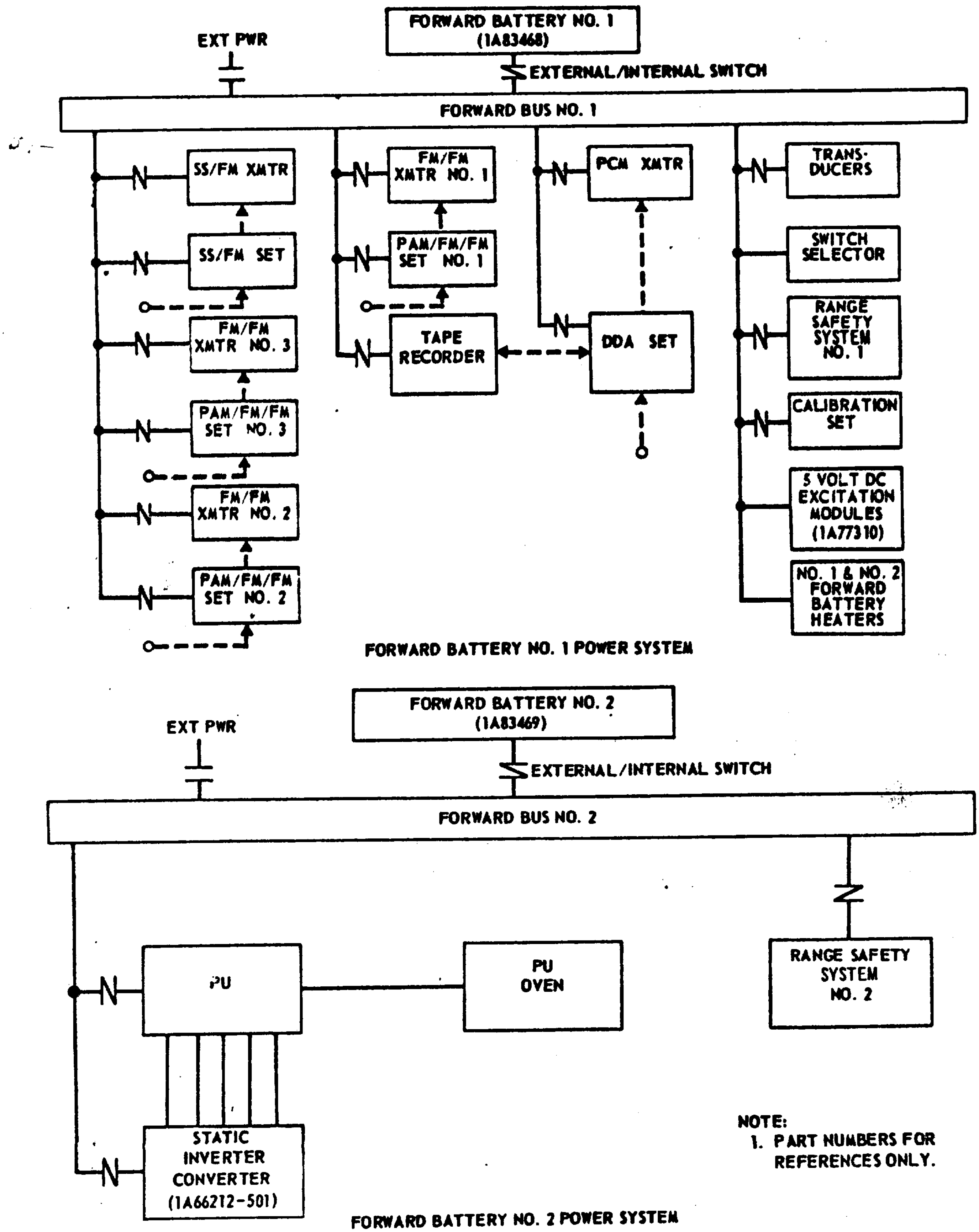
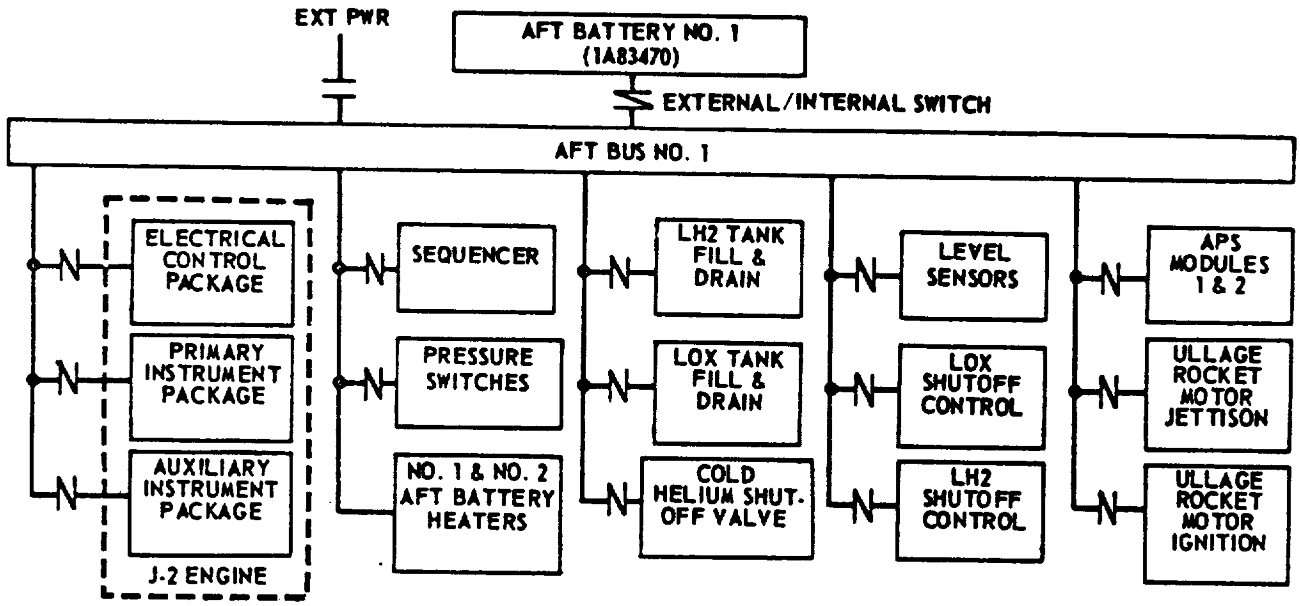
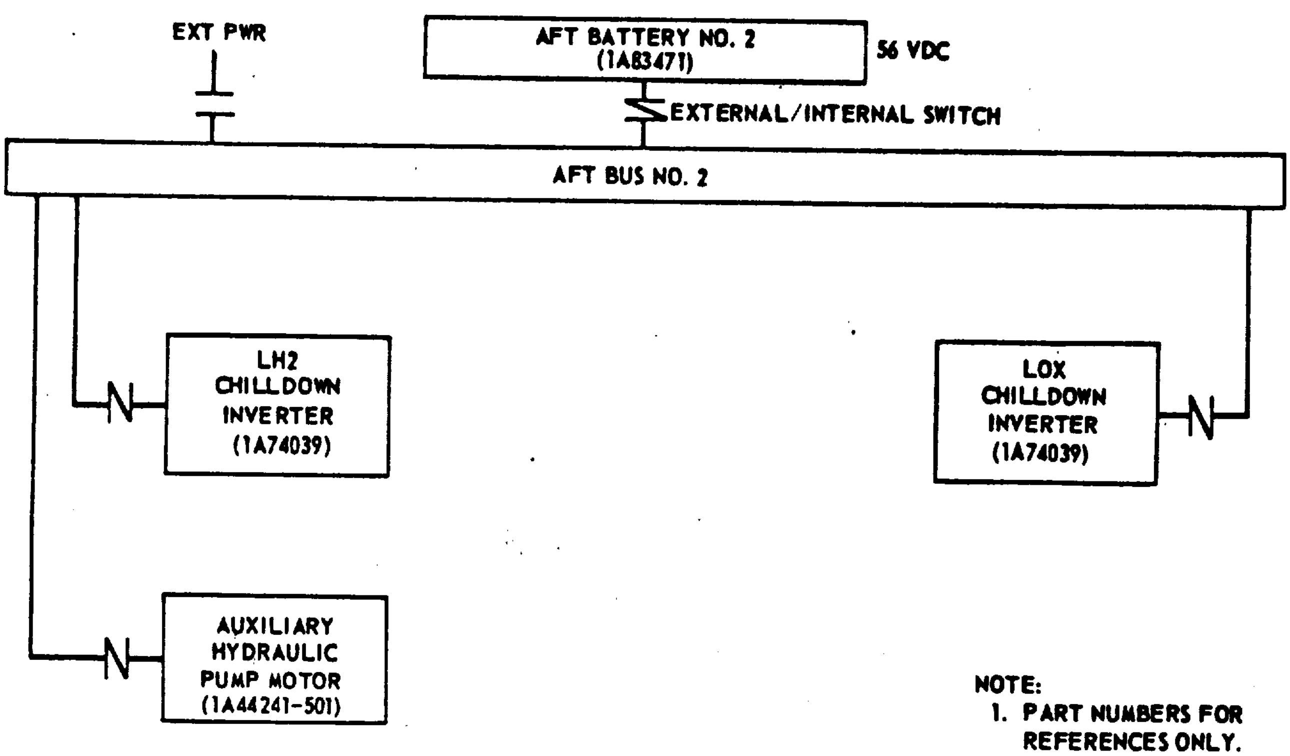


Figure 4-3 Forward Batteries of Electrical Power System



AFT BATTERY NO. 1 POWER SYSTEM



AFT BATTERY NO. 2 POWER SYSTEM

Figure 4-4 Aft Batteries of Electrical Power System

SECTION 5

INSTRUMENTATION

5. INSTRUMENTATION

This section contains the instrumentation and measurement requirements for the stage at Complex Beta and the APS modules at Complex Gamma.

5.1 Stage Testing Instrumentation

For stage acceptance firing at Complex Beta, instrumentation signals will be transmitted from the stage by open-loop RF, coaxial cables, and hardwire.

SS/FM, FM/FM, PCM/FM, and PAM/FM/FM signals will be radiated open-loop RF and will be demodulated and recorded on magnetic tape at the ground stations.

PCM/DDAS signals will be transmitted by coaxial cable from an umbilical connector on the stage to the ground station.

SS/FM, PAM/FM/FM, PCM/FM, and FM/FM measurements are listed in DAC Drawing No. 1B39719: Instrumentation Program and Components List, Saturn IVB-201. Adequate means will be employed to conform to the latest changes of this drawing.

Hardwire measurements from the stage, facilities, and GSE that are specified in CO (Change Order) 230 as amended, Basic Static Firing Measurement Program, will be used to evaluate the stage systems performance. Those measurements so designated, by CO 230 as amended, will be monitored real-time by strip charts, oscillographs, and event recorders and will be recorded permanently on analog or digital magnetic tapes. Appendix 2 of this test plan provides a complete list of all stage-oriented (CO 230 as amended) hardwire measurements.

Hardwire measurements for the S-IVB-201 acceptance firing operations are listed in DAC Drawing No. 1B55758, Instrumentation Program Support Measurements List - Acceptance Test Firing - Saturn S-IVB-201. The drawing provides information on the individual measurements including the operating range of the transducer, frequency response of the recording medium, and the mode of display. The measurements are listed in the following groups: stage ground test, Complex Beta facilities, Complex Gamma facilities, and APS modules measurements.

5.1.1 Prestart, Redline, and Cutoff Parameters

Key parameters, categorized as prestart, redline, and cutoff, have been assigned critical limits for real-time monitoring from the start of propellant loading through firing and engine cutoff. The parameters and predetermined limits are tabulated in Appendix 3. If the recorder trace of a parameter indicates that the limit has been reached, cognizant personnel must initiate the appropriate action. The action taken will depend upon the category of the parameter.

Category	Action
a. Prestart Parameter	If the predetermined limits are exceeded, the operation will be terminated immediately. Operation will resume when acceptable limits are attained.
b. Redline Parameter (MSFC Blueline)	If the predetermined limits are exceeded, the operation may be terminated or continued depending on the judgment of the strip chart monitor.
c. Cutoff Parameter (MSFC Redline)	If the predetermined limits are exceeded, the operation will be terminated immediately.

5.2 APS Testing Instrumentation

For APS module confidence firing at Complex Gamma, instrumentation will be hardwired to the TCC (test control center) and to the IC (instrumentation center). Real-time monitoring will be made with strip chart recordings and panel meters in the TCC and the IC. Recording instruments at the IC will also include oscillographs, a constant-bandwidth FM system, and a PDM system feeding an analog magnetic tape recorder.

The measurements required for APS flight modules No. 1 and No. 2, with recording information, are listed in DAC drawing No. 1B55758, Instrumentation Program Support Measurements List - Static Test Firing - Saturn S-IVB-201.

5.2.1 Redline Parameters

DAC redline parameters and predetermined limits, required during the confidence firing test of APS modules Nos. 1 and 2, are tabulated in Appendix 3. Redline parameter requirements are described in paragraph 5.1.1.

SECTION 6

DATA, EVALUATION, AND DOCUMENTATION

6. DATA, EVALUATION, AND DOCUMENTATION

The information presented in this section defines the responsibilities of the Saturn S-IVB/IB TP&E Committees, at the Huntington Beach Space Systems Center and the Sacramento Test Center, relative to the planning and evaluation of the acceptance firing test program to be conducted at the Sacramento Test Center.

6.1 Test Data

Test data will be qualified by representatives of the Sacramento Test Center TP&E Committee. As soon as available, the data will be qualified to verify that the instrumentation and data systems have operated properly and to establish the validity and reliability of the data.

The Sacramento Test Center Data Processing Section will transmit the following test data to the Space Systems Center Data Processing Section within the time intervals indicated:

a. T +72 hours
   (1) The original of all data tapes
   (2) A copy of the final calibration package (CAT-1 and data book)

b. T +96 hours
   (Not to interfere with processing, evaluating, and qualifying of data for acceptance buyoff)
   (1) The microfilm of qualified strip charts and analog plots (Analog test summary)
   (2) The microfilm of the qualified digital data (Digital test summary)

c. T +10 days
   (1) The original film data
   (2) The original or a microfilm copy of the data processing test summary and sequence recorder readings
   (3) The originals of qualified strip charts, analog plots, and digital data (Test summary).

The Space System Center Data Processing Section, immediately upon receipt of the data specified for T +72 hours and T +96 hours, will produce the following data for NASA/MSFC:

a. Duplicates of the digital tapes with calibrations in engineering units

b. Duplicates of the original vibration and acoustic data tapes.

6.2 Test Evaluation

6.2.1 Sacramento Test Center Evaluation

Immediately following the completion of the stage acceptance static firing test, a test critique will be held during which the test results, based upon real time data, will be summarized. The data from this meeting will be included in the flash acceptance firing test report (TWX), specified in paragraph 6.3.3.

The formal review meeting with NASA/MSFC will be held within T +7 working days for buyoff of the acceptance test objectives. The cognizant design branch representatives will present the evaluation of pertinent objectives. Such evaluation will be presented with pertinent acceptance firing data extrapolated to the S-IVB-201 flight condition. Buyoff of acceptance test objectives will be made jointly by the DAC and NASA/MSFC representatives. At this time, only a perfunctory evaluation will be made of the research and development objectives.

Using qualified data, preliminary evaluation of test results will be made and documented in the preliminary acceptance firing test report, specified in paragraph 6.3.4.

6.2.2 Space Systems Center Evaluation

A detailed evaluation will be made of the analog, digital, and film data from the acceptance firing test. Correlation will be made with data gathered from previous Sacramento Test Center and Space Systems Center tests. Computer supported analyses will be made to derive a more refined evaluation of test results. The final detailed evaluation will be documented in the acceptance firing test report, specified in paragraph 6.3.5.

6.3 Test Documentation

Test documentation responsibilities for the Sacramento Test Center and Space Systems Center TP&E Committees are defined in the following paragraphs.

6.3.1 Daily Progress Report

The Sacramento Test Center TP&E Committee chairman will make a daily progress and activities report to the Space Systems Center TP&E Committee chairman. Stage reporting will commence when the stage is installed on the Complex Beta test stand. Auxiliary propulsion system reporting will be required during the period that either module is installed on a test fixture in a Complex Gamma test cell.

6.3.2 Test Request

A test request will be issued, by the Sacramento Test Center TP&E Committee, to outline all necessary information for conducting each test. A deviation test request will be issued to document minor last-minute changes.

6.3.3 Flash Acceptance and Confidence Firing Test Reports (TWX)

Within 24 hours after the completion of acceptance firing program test of the deliverable stage or of the confidence firing test of an APS flight module, the Sacramento Test Center TP&E Committee will teletype a brief flash report to NASA/MSFC and to the Space Systems Center TP&E Committee chairman. The TWX will contain available pertinent information and a qualitative description of the test.

6.3.4 Preliminary Acceptance and Confidence Firing Test Reports

Within 15 working days after completion of acceptance or confidence firing tests, the Sacramento Test Center TP&E Committee will submit a preliminary firing test report to NASA. Copies of the report will be transmitted to the Space Systems Center TP&E Committee chairman. The report will include preliminary test data and will describe the objectives accomplished during the test. Primary emphasis will be placed on analysis of test anomalies to define possible causes of irregularities and to suggest possible corrective action. Quantitative stage system performance values will be corrected to the S-IVB-201 flight condition.

6.3.5 Final Acceptance Firing Test Report

Within 60 days after completion of the stage acceptance firing test, the Space Systems Center TP&E Committee will supply a final acceptance firing test report to NASA/MSFC. This report will include the following: the changes to the test configuration from those described in this test plan; conclusions to encompass the effectiveness of the acceptance and confidence firing test operations and the overall performance of the S-IVB-201 stage; performance evaluation of all stage subsystems and structures; performance evaluation of all Sacramento Test Center GSE common to KSC operations; evaluation of operations (procedures and sequences) pertinent to KSC; and history of significant S-IVB-201 stage events at STC. The report will present quantative stage system performance values that will have been corrected to the S-IVB-201 flight conditions.

6.4 Motion Picture Requirements

Specific coverage will be determined by the Sacramento Test Center TP&E Committee. Timing will be provided on all film.

6.5 Reliability Requirements

Data will be obtained for reliability analysis throughout the entire acceptance firing activities for generation of information concerning the operational characteristics of critical components and the reliability of system operation. This information will be furnished in one or more of the following forms:

a. Failure and Rejection Reports - Hardware failures or malfunctions will be documented on Douglas "Failure and Rejection Report" forms Nos. X37-104 and X37-104A per SPB-MSSD-710.2 and SPM 023. This reporting method will be handled as a function of the Sacramento Test Center Quality Control Group.

b. Operating Time/Cycle Data - Records of operating time/cycles will be required on all time/cycle significant items listed in the latest revision of S-IVB Design Memo No. 96. This task will be conducted in accordance with Standard Practice Bulletin MSSD-701 and Technical Operating Procedure No. 018.

c. Failure Data Reports - Component failures or malfunctions of either the S-IVB stage or ground support equipment items requiring special consideration or expedited corrective action will also be documented on the Engineering Reliability Failure Data Report form No. L-260-404B as a function of the Sacramento Test Center Reliability Analysis Group. Of major concern will be those items specified as Flight Critical Items in DAC Report No. SM-46667: Reliability Mathematical Model, Saturn IB/SIVB-201 Stage.

d. Supplemental Failure Analysis Reports - Formal failure analysis reports will be required for all critical hardware item failures occurring during checkout or test operations when the cause of failure cannot be readily determined. This failure analysis effort will be documented on Douglas Supplemental Failure Analysis Report forms Nos. 60-732 and 60-732-1 per SPB-MSSD-710.3.

e. Countdown History - The Sacramento Reliability Analysis Group, in the capacity of Historian, will monitor all major scheduled engineering tests and countdowns associated with the S-IVB stage acceptance firing. All failures and deficiencies encountered during these activities will be documented in the Historian reports for transmittal with the test data packages.

f. Hardware Failure Summary - The Reliability Analysis Section will submit a hardware failure summary for inclusion in the final stage acceptance firing report. The summary will include all hardware failures occurring from initiation of countdown through J-2 engine cutoff and will also note any deficiencies subsequently disclosed.

APPENDIX 1

ABBREVIATIONS

APPENDIX 1

ABBREVIATIONS

ac	Alternating Current
ACT	Actuator
AGC	Automatic Gain Control
amps	Amperes
APS	Auxiliary Propulsion System
ASI	Augmented Spark Ignition
ASSY	Assembly
Auto	Automatic
AUX	Auxiliary
BAL	Balance
BTL	Bottle
B/W	Black and White
BYP	Bypass
CAT-1	Computer Application Telemetry No. 1
CAV	Cavity
CHAMB	Chamber
CHLDWN	Chilldown
CONT	Control
CO	Change Order
C/O	Checkout
cps	Cycles per second
DAC,DACO	Douglas Aircraft Company
dc	Direct Current
DDAS	Digital Data Acquisition System
DIFF	Differential
DIFFUS	Diffuser
DISCH	Discharge
DIST	Distribution
EBW	Exploding Bridge Wire
E/I	External/Internal
ELECT	Electronic, Electrical
ENER	Energized
ENG	Engine
ER	Event Recorder
F	Fahrenheit
FIG	Figure
FLT	Flight
FM	Frequency Modulation
FWD	Forward
GG	Gas Generator
GH_2	Gaseous Hydrogen
GN_2	Gaseous Nitrogen
GSE	Ground Support Equipment
He	Helium
HYD	Hydraulic
IC	Instrumentation Center
IU	Instrument Unit
IGN	Ignition
INJ	Injector, Injection
INT	Internal
INV	Inverter
k	Kilohm
KSC	Kennedy Space Center
lb	Pound
LH_2	Liquid Hydrogen
LOX,LO_2	Liquid Oxygen

APPENDIX 1

ABBREVIATIONS (Continued)

M&A	Maintenance and Assembly
ma	Milliampere
MANF.	Manifold
MOD	Module
MSFC	Marshall Space Flight Center
MSSD	Missile Space Systems Division
NAA	North American Aviation
NASA	National Aeronautics & Space Administration
NOZ	Nozzle
OSC	Oscillograph
OXID	Oxidizer
P	Pitch
PAM	Pulse Amplitude Modulation
PPM	Parts Per Million
PCM	Pulse Code Modulation
PDM	Pulse Duration Modulation
PNEU	Pneumatic
PL	Plane
PMR	Program Mixture Ratio
POS(IT)	Position
POT	Potentiometer
PRESS	Pressure
PRIM	Primary
PROP	Propulsion, Propellant
psia	Pounds per square inch absolute
psid	pounds per square inch differential
psig	pounds per square inch gauge
PU,P/U	Propellant Utilization
R	Rankine
RAD	Radial
REG	Regulator
RF, R/F	Radio Frequency
RMS	Root Mean Square
RSS	Root Sum Square
rpm	Revolutions Per Minute
SC	Strip Chart
scfm	Standard Cubic Foot Per Minute
SERVO	Servomechanism
SIG	Signal
SOL	Solenoid
SOV	Shutoff Valve
SPB	Standard Practice Bulletin
SPM	Standard Practice Memorandum
SPT	Support
SS	Single Sideband
STC	Sacramento Test Center
STRT	Start
SUP	Supply
SW	Switch
SYS	System
TCC	Test Control Center
TEMP	Temperature
THR	Thrust
TK	Tank
T/M,TM	Telemetry
TP&E	Test Planning & Evaluation
TRW	Thompson Ramo Wooldridge
TURB	Turbine
TWX	Teletypewriter Exchange

APPENDIX 1

ABBREVIATIONS (Continued)

VCL	Vehicle Checkout Laboratory
vdc	Volts Direct Current
VIB	Vibration
VLV	Valve
VOLT	Voltage
VSWR	Voltage Standing Wave Ratio
XMTR	Transmitter
Y	Yaw

APPENDIX 2

S-IVB BASIC STATIC FIRING MEASUREMENTS

APPENDIX 2
S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM DIGITAL	TAPE SYSTEM ANALOG	DISPLAY SC	DISPLAY OSC	DISPLAY ER
C0642-403	TEMP - RESERVOIR OIL	-60 to +325°F	4	X		X		
C0644-401	TEMP - FUEL PUMP DISCH	-425 to -400°F	5	X				
C0645-401	TEMP - THR CHAMB JACKET	-425 to +100°F	1.7	X		X		
C0646-401	TEMP - FUEL INJECTION	-425 to +100°F	5	X			X	
C0647-401	TEMP - OXID PUMP BEARING COOLANT	-300 to -250°F	5	X		X		
C0648-401	TEMP - OXID PUMP DISCH	-300 to -250°F	5	X				
C0649-401	TEMP - GH2 STRT BOTTLE	-350 to +100°F	5	X		X		
C0650-401	TEMP - GG FUEL BLEED VLV	-425 to -375°F	5	X		X		
C0651-401	TEMP - GG OXID BLEED VLV	-300 to -250°F	5	X		X		
C0654-401	TEMP - FUEL TURB OUTLET	0 to 1,800°F	2	X			X	
C0655-401	TEMP - BYP NOZ INLET	0 to 1,200°F	2	X			X	
C0657-401	TEMP - ELEC CONT ASSY	-300 to +200°F	2	X		X		
C0658-403	TEMP - FUEL PUMP INLET	-425 to -413°F	5	X		X		
C0659-403	TEMP - OXID PUMP INLET	-250 to -300°F	5	X		X		
C0661-405	TEMP - COLD HE SPHERE NO. 4 GAS	-435 to +100°F	5	X				
C0662-404	TEMP - OXID TANK HE INLET	-425 to +100°F	5	X		X		
C0755-B03	TEMP - SAFETY CUTOFF GG EXHAUST	32 to 2,200°F	10	X		X	X	
D0508-403	PRESS - HYD SYS	1,500-4,000 psia	10	X		X	X	
D0509-403	PRESS - RESERVOIR OIL	0 to 300 psia	10	X		X		
D0510-403	PRESS - DIFF ENG "P" ACT	±6,000 psid	100	X			X	
D0511-403	PRESS - DIFF ENG "Y" ACT	±6,000 psid	100	X			X	

APPENDIX 2 (Continued)

S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
D0514-401	PRESS - ASI CHAMB	0 to 800 psig	100	X			X	
D0515-401	PRESS - FUEL PUMP BAL PISTON SUMP	0 to 750 psig	10	X		X		
D0516-401	PRESS - FUEL PUMP DISCH	0 to 1,500 psig	100	X			X	
D0518-401	PRESS - MAIN FUEL INJECTION	0 to 1,000 psig	100	X		X	X	
D0521-401	PRESS - OXID PUMP PRIM SEAL CAV	0 to 50 psig	10	X		X		
D0522-401	PRESS - OXID PUMP DISC	0 to 1,500 psig	100	X			X	
D0524-401	PRESS - THR CHAMB J-2 ENG	0 to 1,000 psig	10	S		X		
D0525-401	PRESS - GH2 STRT BTL	0 to 1,500 psig	25	X		X	X	
D0527-401	PRESS - GG FUEL INJ	0 to 1,000 psig	25	X			X	
D0529-401	PRESS - GG OXID INJ	0 to 1,000 psig	25	X			X	
D0530-401	PRESS - GG CHAMB	0 to 1,000 psig	100	X			X	
D0532-401	PRESS - BYP NOZ INLET	0 to 150 psig	10	X				
D0533-401	PRESS - OXID TURB OUTLET	0 to 100 psig	10	X				
D0534-401	PRESS - CONT HE SUP	0 to 3,500 psig	10	X		X		
D0535-401	PRESS - ENG REG OUTLET	0 to 750 psig	10	X		X		
D0536-403	PRESS - FUEL PUMP INLET	0 to 50 psig	10	X		X	X	
D0537-403	PRESS - OXID PUMP INLET	0 to 50 psig	10	X		X	X	
D0538-401	PRESS - H2 TAPOFF ORIFICE OUTLET	0 to 1,000 psig	10	X				
D0539-410	PRESS - FUEL TANK ULLAGE	0 to 50 psig	10	X		X		
D0540-424	PRESS - OXID TANK ULLAGE	0 to 50 psig	10	X		X		
D0541-403	PRESS - HE (AMBIENT) SPHERE	0 to 3,500 psig	10	X		X		
D0542-405	PRESS - COLD HE SPHERE	0 to 3,500 psig	10	X		X		
D0544-401	PRESS - THR CHAMB J-2 ENG	0 to 1,000 psig	100				X	

APPENDIX 2 (Continued)
S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
D0545-407	PRESS - COMMON BULKHEAD INT	0 to 25 psia	10	X		X		
D556-401	PRESS - LOX PUMP BEARING COOLANT	0 to 500 psig	10	X		X		
D0851-B21	PRESS - ENG DIFFUS WATER MANF	0 to 150 psia	10	X		X		
E0555-401	VIB - OXID TURB PUMP RAD	±150 g	10,000		X			
E0556-401	VIB - FUEL TURB PUMP RAD	±150 g	10,000		X			
E0706-B03	VIB - VIB SAFETY CUTOFF NO. 2 THR	±150 g	10,000		X			
E0707-B03	VIB - VIB SAFETY CUTOFF NO. 1 THR	±150 g	10,000		X			
F0001-401	FLOWMETER - OXID	0 to 3,000 gpm	400	X			X	
F0002-401	FLOWMETER - FUEL	0 to 9,000 gpm	400	X			X	
G0503-401	POS - P/U SYS RATIO VLV	0 to 5 vdc	2.4	X			X	
G0504-403	POS - ACT PISTON POT P PL	0 to 5 vdc	20				X	
G0505-403	POS - ACT PISTON POT YAW PL	0 to 5 vdc	20				X	
G0506-401	POS - MAIN FUEL VLV	0 to 100%	2.4	X			X	
G0507-401	POS - MAIN OXID VLV	0 to 100%	2.4	X			X	
G0508-401	POS - STRT TK DISCH CONT VLV	0 to 100%	2.4	X			X	
G0509-401	POS - GG VLV	0 to 100%	2.4	X			X	
G0510-401	POS - OXID TURB BYP VLV	0 to 100%	2.4	X			X	

APPENDIX 2 (Continued)

S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
K0512-404	EVENT - FUEL CHLDWN INV ENERG	0 to 30 vdc	2.4					X
K0513-404	EVENT - AUX HYD PUMP ENERG	0 to 30 vdc	2.4					X
K0515-404	EVENT - FUEL TANK VENT BOOST CLOSE PILOT VLV ENERG	0 to 30 vdc	2.4					X
K0516-404	EVENT - FUEL TANK VENT OPEN PILOT VLV ENERG	0 to 30 vdc	2.4					X
K0519-404	EVENT - OXYGEN CHLDWN INV ENERG	0 to 30 vdc	2.4					X
K0522-404	EVENT - ENG CUTOFF ENERG	0 to 30 vdc	2.4				X	X
K0530-401	EVENT - ENG READY SIG	0 to 32 vdc	100					X
K0531-401	EVENT - ENERG HE CONT SOL	0 to 32 vdc	100					X
K0532-410	EVENT - FUEL TANK VENT VLV NO. 1 CLOSED	0 to 32 vdc	100					X
K0533-424	EVENT - OXID TANK VENT VLV NO. 1 CLOSED	0 to 32 vdc	100					X
K0534-401	EVENT - THR CHAMB FUEL INJECTION TEMP OK	ON-OFF	100					X
K0535-401	EVENT - ENERG IGN PHASE CONT SOL	0 to 32 vdc	100					X
K0536-401	EVENT - ENERG STRT TANK DISCH SOL	0 to 32 vdc	100					X
K0537-401	EVENT - IGN DETECTED	0 to 32 vdc	200				X	X
K0538-401	EVENT - ENERG MAINSTAGE CONT SOL	0 to 32 vdc	100					X
K0539-401	EVENT - ENG CUTOFF LOCK-IN	0 to 32 vdc	100				X	X
K0540-404	EVENT - FUEL PREVALVE OPEN	0 to 32 vdc	100					X
K0541-403	EVENT - OXID PREVALVE OPEN	0 to 32 vdc	100					X
K0542-410	EVENT - FUEL TANK VENT VLV NO. 1 OPEN	0 to 32 vdc	100					X

APPENDIX 2 (Continued)

S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
K0543-404	EVENT - OXID TANK VENT VLV NO. 1 OPEN	0 to 32 vdc	100					X
K0544-409	EVENT - OPEN FUEL SOV CHILL SYS	0 to 32 vdc	100					X
K0545-424	EVENT - OPEN OXID SOV CHILL SYS	0 to 32 vdc	100					X
K0546-404	EVENT - FUEL FILL VLV OPEN	0 to 32 vdc	100					X
K0547-404	EVENT - OXID FILL VLV OPEN	0 to 32 vdc	100					X
K0549-404	EVENT - FUEL PREVALVE CLOSED	0 to 32 vdc	100					X
K0550-403	EVENT - OXID PREVALVE CLOSED	0 to 32 vdc	100					X
K0551-409	EVENT - CLOSED FUEL SOV, CHILL SYS	0 to 32 vdc	100					X
K0552-424	EVENT - CLOSED OXID SOV CHILL SYS	0 to 32 vdc	100					X
K0553-404	EVENT - OXID FILL VLV CLOSED	0 to 32 vdc	100					X
K0554-404	EVENT - FUEL FILL VLV CLOSED	0 to 32 vdc	100					X
K0555-401	EVENT - STRT TANK PRESSURIZED	0 to 28 vdc	2.4					X
K0556-404	EVENT - ENG STRT COMMAND	0 to 30 vdc	2.4				X	X
K0557-401	EVENT - CLOSED SW FUEL BLEED VLV	0 to 32 vdc	100					
K0558-401	EVENT - CLOSED SW LOX BLEED VLV	0 to 32 vdc	100					
K0559-403	EVENT - AMBIENT HE SPHERE MINIMUM LIFTOFF PRESS SW ENERG	0 to 30 vdc	2.4					X
K0560-405	EVENT - COLD HE SPHERE MINIMUM LIFTOFF PRESS SW ENERG	0 to 30 vdc	2.4					X
K0561-410	EVENT - CLOSED FUEL TANK DIRECTIONAL CONT VENT VLV PORT "C"	0 to 32 vdc	100					X
K0562-410	EVENT - CLOSED FUEL TANK DIRECTIONAL CONT VENT VLV PORT "D"	0 to 32 vdc	100					X

APPENDIX 2 (Continued)
S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
K0563-404	EVENT - LOX TANK PREPRESSURE AND FLT CONT PRESS SW ENERG	0 to 30 vdc	2.4					X
K0564-404	EVENT - FUEL TANK PREPRESSURE AND FLT CONT PRESS SW ENERG	0 to 30 vdc	2.4					X
K0565-404	EVENT - LOX CHLDWN PUMP PURGE CONT MOD SOL VLV ENERG	0 to 30 vdc	2.4					X
K0566-404	EVENT - ENG PUMP PURGE CONT MOD SOL VLV ENERG	0 to 30 vdc	2.4					X
K0567-404	EVENT - CONT HE SOV ENERG	0 to 30 vdc	2.4					X
K0570-404	EVENT - LH2 PRESS CONT MOD PREPRESSURIZATION SOL VLV ENERG	0 to 30 vdc	2.4					X
K0571-404	EVENT - LOX TANK COLD HE SHUTOFF SOL VLV ENERG	0 to 30 vdc	2.4					X
K0572-401	EVENT - MAINSTAGE OK PRESS SW A DEPRESSURIZED	0 to 28 vdc	2.4				X	X
K0573-401	EVENT - MAINSTAGE OK PRESS SW B DEPRESSURIZED	0 to 28 vdc	2.4				X	X
K0574-404	EVENT - LOX TANK VENT BOOST CLOSE PILOT VLV ENERG	0 to 30 vdc	2.4					X
K0575-404	EVENT - LOX TANK VENT OPEN PILOT VLV ENERG	0 to 30 vdc	2.4					X
K0576-404	EVENT - FUEL AND LOX PREVALVE CLOSE PILOT VLV ENERG	0 to 30 vdc	2.4					X
K0577-404	EVENT - FUEL AND LOX RECIRCULATION VLV CLOSE PILOT VLV ENERG	0 to 30 vdc	2.4					X
K0578-404	EVENT - COLD HE SAFE PRESS SW OFF	0 to 30 vdc	2.4					X

APPENDIX 2 (Continued)
S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
K0580-411	EVENT - LH2 TANK LOADING PRESS SW ON	0 to 30 vdc	2.4					X
K0581-404	EVENT - LH2 ORBITAL VENT CLOSED PRESS SW ON	0 to 30 vdc	2.4					X
K0583-411	EVENT - LH2 TANK SAFE PRESS SW OFF	0 to 30 vdc	2.4					X
K0584-404	EVENT - LOX TANK MINIMUM LIFTOFF PRESS SW ON	0 to 30 vdc	2.4					X
K0585-404	EVENT - LOX TANK LOADING PRESS SW ON	0 to 30 vdc	2.4					X
K0586-404	EVENT - LOX TANK SAFE PRESS SW OFF	0 to 30 vdc	2.4					X
K0587-404	EVENT - AMBIENT HE SPHERE SAFT PRESS SW OFF	0 to 30 vdc	2.4					X
K0828-B03	EVENT - GG OVERTEMPERATURE CUTOFF	0 to 32 vdc	100				X	X
K0829-B03	EVENT - VIB SAFETY CUTOFF NO. 2	0 to 32 vdc	100				X	X
K0830-B03	EVENT - VIB SAFETY CUTOFF NO. 1	0 to 32 vdc	100				X	X
K0887-B03	EVENT - ASI SPARK NO. 1 OK	0 to 28 vdc	2.4					X
K0888-B03	EVENT - ASI SPARK NO. 2 OK	0 to 28 vdc	2.4					X
K0889-B03	EVENT - GG SPARK NO. 1 OK	0 to 28 vdc	2.4					X
K0890-B03	EVENT - GG SPARK NO. 2 OK	0 to 28 vdc	2.4					X
K2729-B03	EVENT - FUEL PUMP OVERSPEED CUTOFF	0 to 30 vdc	200				X	X
K2730-B03	EVENT - LOX PUMP OVERSPEED CUTOFF	0 to 30 vdc	200				X	X
L0504-403	LEVEL - RESERVOIR OIL	0 to 100%	2.4	X		X		

APPENDIX 2 (Continued)
S-IVB BASIC STATIC FIRING MEASUREMENTS

MEASUREMENT NO.	MEASUREMENT TITLE	RANGE	RESPONSE CPS	TAPE SYSTEM		DISPLAY		
				DIGITAL	ANALOG	SC	OSC	ER
M0514-401	VOLT - J-2 ENG CONT BUS	0 to 30 vdc	2.4	X		X		X
M0515-401	VOLT - J-2 ENG IGN BUS	0 to 30 vdc	2.4	X		X		X
M0704-B20	CURRENT - SERVO VLV INPUT SIGNAL "P"	±60 ma	20				X	
M0705-B20	CURRENT - SERVO VLV INPUT SIGNAL "Y"	±60 ma	20				X	
M0710-B03	VOLT - ENG P POS COMMAND (AMPLIFIER INPUT SIG)	±7.5 vdc	25				X	
M0711-B03	VOLT - ENG YAW POS COMMAND (AMPLIFIER INPUT SIG)	±7.5 vdc	25				X	
N0703-B03	MISC - ENG SPT LINK LOAD P PL	±50 k	50	X		X		
N0704-B03	MISC - ENG SPT LINK LOAD YAW PL	±50 k	50	X		X		
T0001-401	SPEED - OXID PUMP	0 to 12,000 rpm	400		X		X	
T0002-401	SPEED - FUEL PUMP	0 to 30,000 rpm	400		X		X	

APPENDIX 3

S-IVB-201 PRESTART, REDLINE, AND CUTOFF PARAMETERS

APPENDIX 3

S-IVB-201 PRESTART, REDLINE, AND CUTOFF PARAMETERS

Appendix 3 consists of four parts. The first part, table AP-1, is the list of the prestart, redline, and cutoff parameters required for the S-IVB-201 stage acceptance firing test at Complex Beta test stand III. The second part, table AP-2, is the list of the prestart, redline, and cutoff parameters required for the confidence firing tests of the S-IVB-201 APS modules at Complex Gamma. The third part, NOTES, supplies additional qualifying information as denoted in the last column of the lists. The fourth part, figures AP-1 through AP-4, consists of graphs that define critical limits for the LOX and LH2 pump inlet pressures and temperatures.

Definition of Terms

Prestart - If predetermined limits are exceeded, the operation will be terminated immediately. Operation will be resumed when acceptable limits are attained.

Redline - (MSFC Blueline) If predetermined limits are exceeded, the operation may be terminated or it may continue, depending on the judgement of the strip chart monitor.

Cutoff - (MSFC Redline) If predetermined limits are exceeded, the operation will be terminated immediately.

TABLE AP-1

S-IVB-201 STAGE ACCEPTANCE FIRING TEST - PRESTART, REDLINE, AND CUTOFF PARAMETERS

MEAS. NO.	TITLE	PRESTART MIN	PRESTART MAX	REDLINE MIN	REDLINE MAX	CUTOFF MIN	CUTOFF MAX	NOTES
C400-401	Temp-Engine Control Helium	160°R	260°R					
C402-401	Temp-Gas Generator Combustor Body No. 1						1910°R	
C403-401	Temp-Gas Generator Combustor Body No. 2						1910°R	
C642-403	Temp-Reservoir Oil	450°R	635°R	450°R	725°R		735°R	
C645-401	Temp-Thrust Chamber Jacket	210°R	310°R					1
C647-401	Temp-Oxidizer Pump Bearing Coolant		200°R				200°R	
C649-401	Temp-GH2 Start Bottle	160°R	260°R					2
C658-403	Temp-Fuel Pump Inlet	Fig AP-1	Fig AP-1			Fig AP-2	Fig AP-2	3
C659-403	Temp-LOX Pump Inlet	Fig AP-3	Fig AP-3			Fig AP-4	Fig AP-4	3
C661-405	Temp-Cold Helium Sphere No. 4 Gas		50°R					
C662-404	Temp-Oxidizer Tank Helium Inlet						560°R	4
C699-403	Temp-Hydraulic Pump Inlet Oil	450°R	610°R	450°R	735°R			
C753-B03	Temp-Fluid Thermo-Conditioner Supply			495°R	540°R			
C755-B03	Temp-Gas Generator Combustion Safety Cutoff							5

TABLE AP-1

S-IVB-201 STAGE ACCEPTANCE FIRING TEST - PRESTART, REDLINE, AND CUTOFF PARAMETERS (Continued)

MEAS. NO.	TITLE	PRESTART		REDLINE		CUTOFF		NOTES
		MIN	MAX	MIN	MAX	MIN	MAX	
D508-403	Press-Hydraulic System	3500 psia	3800 psia	3,000 psia	3,800 psia	2,400 psia		6
D509-403	Press-Reservoir Oil	145 psia	275 psia	155 psia	235 psia	145 psia	275 psia	7,8
D515-401	Press-Fuel Pump Balance Piston					315 psia	815 psia	9
D521-401	Press-Oxidizer Primary Seal Cavity		15 psia		45 psia		50 psia	10
D524-401	Press-Thrust Chamber J2 Engine					540 psia	843 psia	
D525-401	Press-GH2 Start Bottle	1200 psia	1300 psia				1000 psia	2
D534-401	Press-Control Helium Supply	1,500 psia	3,750 psia		3,200 psia	800 psia		
D536-403	Press-Fuel Pump Inlet	Fig AP-1	Fig AP-1			Fig AP-2	Fig AP-2	3
D537-403	Press-Oxidizer Pump Inlet	Fig AP-3	Fig AP-3			Fig AP-4	Fig AP-4	3
D539-410	Press-Fuel Tank Ullage	31 psia	42 psia		39 psia		43 psia	
D540-424	Press-Oxidizer Tank Ullage	37 psia	44 psia		41 psia		45 psia	
D541-403	Press-Helium (Ambient) Sphere	2,800 psia	3,300 psia	600 psia	3,300 psia		3,500 psia	
D542-405	Press-Cold Helium Sphere	2,800 psia	3,300 psia		3,300 psia		3,500 psia	11

TABLE AP-1

S-IVB-201 STAGE ACCEPTANCE FIRING TEST - PRESTART, REDLINE, AND CUTOFF PARAMETERS (Continued)

MEAS. NO.	TITLE	PRESTART		REDLINE		CUTOFF		NOTES
		MIN	MAX	MIN	MAX	MIN	MAX	
D545-407	Press-Common Bulkhead Internal		3.5 psia		3.5 psia			12
D557-403	Press-Accumulator GN2	3,500 psia	3,800 psia		3,800 psia			13
D558-403	Press-Fuel Vent Valve Pneumatic Supply	450 psia	550 psia	440 psia	550 psia	400 psia	650 psia	
D559-415	Press-Fuel Tank Ullage Module 2 APS	195 psia	205 psia	165 psia	227 psia		350 psia	14
D560-415	Press-Oxidizer Tank Ullage Module 2 APS	195 psia	205 psia	165 psia	227 psia		350 psia	14
D565-403	Press-Auxiliary Hydraulic Pump Air Tank	100 psia						
D711-B03	Press-Deflector Water	110 psia				110 psia		
D851-B21	Press-Engine Diffuser	56 psia	87 psia			56 psia	87 psia	1,15
D868-B03	Press-Fwd. Skirt				6 in. H20			
E706-B03	Vib-Vibration Safety Cutoff No. 2 Thrust							16
E707-B03	Vib-Vibration Safety Cutoff No. 1 Thrust							16

TABLE AP-1

S-IVB-201 STAGE ACCEPTANCE FIRING TEST - PRESTART, REDLINE, AND CUTOFF PARAMETERS (Continued)

MEAS. NO.	TITLE	PRESTART		REDLINE		CUTOFF		NOTES
		MIN	MAX	MIN	MAX	MIN	MAX	
G503-401	Posit-PU System Ratio Valve	26 deg	29 deg					17
G504-403	Posit - Actuator Piston Pot Pitch							18
G505-403	Posit - Actuator Piston Pot Yaw							18
L504-403	Level-Reservoir Oil					8%		6,19
M514-401	Voltage-J2 Engine Control Bus	26 vdc	30 vdc			24 vdc	30 vdc	20
M515-401	Voltage-J2 Engine Ignition Bus	26 vdc	30 vdc			24 vdc	30 vdc	20,21
M534-404	Current-Internal Aft Bus No. 1				70 amps		100 amps	22
M535-404	Current-Internal Aft Bus No. 2				120 amps		200 amps	
M536-411	Current-Internal Forward Bus No. 1				70 amps		100 amps	
M537-411	Current-Internal Forward Bus No. 2				10 amps		15 amps	23
M712-B03	Voltage-Load Aft Power Supply No. 2					48 vdc	64 vdc	

TABLE AP-1

S-IVB-201 STAGE ACCEPTANCE FIRING TEST - PRESTART, REDLINE, AND CUTOFF PARAMETERS (Continued)

MEAS. NO.	TITLE	PRESTART		REDLINE		CUTOFF		NOTES
		MIN	MAX	MIN	MAX	MIN	MAX	
M713-B03	Voltage-Load Aft Power Supply No. 1					24 vdc	30 vdc	
M714-B03	Voltage-Load Forward Power Supply No. 2					24 vdc	32 vdc	
M715-B03	Voltage-Load Forward Power Supply No. 1					24 vdc	32 vdc	
N703-B03	Misc-Engine Support Link Load-Pitch						± 3,000 lbs	24
N704-B03	Misc-Engine Support Link Load-Yaw						± 3,000 lbs	24
T502-401	Speed-LOX PUMP AC Output						9,500 rpm	25
T503-401	Speed-Fuel Pump AC Output						28,400 rpm	25

TABLE AP-2

S-IVB-201 APS MODULES CONFIDENCE FIRING TESTS - PRESTART, REDLINE, AND CUTOFF PARAMETERS

MEAS. NO.	TITLE	PRESTART		REDLINE		CUTOFF		NOTES
		MIN	MAX	MIN	MAX	MIN	MAX	
D064-414	Press-Helium Regulator Inlet Module 1 APS	2,000 psia	3,100 psia					26
D068-415	Press-Helium Regulator Inlet Module 2 APS	2,000 psia	3,100 psia					26
D078-414	Press-Attitude Control Chamber 1-1 APS			75 psia	125 psia			26
D079-414	Press-Attitude Control Chamber 1-2 APS			75 psia	125 psia			26
D080-414	Press-Attitude Control Chamber 1-3 APS			75 psia	125 psia			26
D081-415	Press-Attitude Control Chamber 2-1 APS			75 psia	125 psia			26
D082-415	Press-Attitude Control Chamber 2-2 APS			75 psia	125 psia			26
D083-415	Press-Attitude Control Chamber 2-3 APS			75 psia	125 psia			26
D089-414	Press-Fuel Tank Ullage Module 1 APS	195 psia	205 psia	165 psia	227 psia		350 psia	26
D090-414	Press-Oxidizer Tank Ullage Module 1 APS	195 psia	205 psia	165 psia	227 psia		350 psia	26
D091-415	Press-Fuel Tank Ullage Module 2 APS	195 psia	205 psia	165 psia	227 psia		350 psia	26
D092-415	Press-Oxidizer Tank Ullage Module 2 APS	195 psia	205 psia	165 psia	227 psia		350 psia	26

TABLE AP-2

S-IVB-201 APS MODULES CONFIDENCE FIRING TESTS - PRESTART, REDLINE, AND CUTOFF PARAMETERS (Continued)

MEAS. NO.	TITLE	PRESTART		REDLINE		CUTOFF		NOTES
		MIN	MAX	MIN	MAX	MIN	MAX	
D093-414	Press-Fuel Tank Outlet Module 1 APS					160 psia	240 psia	26
D094-414	Press-Oxidizer Tank Outlet Module 1 APS					160 psia	240 psia	26
D095-415	Press-Oxidizer Tank Outlet Module 2 APS					160 psia	240 psia	26
D096-415	Press-Fuel Tank Outlet Module 2 APS					160 psia	240 psia	26
N037-414	Quantity-Oxidizer Tank Module 1 APS	5 inches	10 inches					26
N038-415	Quantity-Oxidizer Tank Module 2 APS	5 inches	10 inches					26
N039-414	Quantity-Fuel Tank Module 1 APS	5 inches	10 inches					26
N040-415	Quantity-Fuel Tank Module 2 APS	5 inches	10 inches					26

APPENDIX 3

NOTES

1. In order to maintain the preconditioned hardware temperature, the external thrust chamber igniter and the diffuser coolant water shall not be turned on more than 5 seconds prior to engine start.

2. The GH2 start bottle must be chilled to less than 260°R whenever it is pressurized to more than 1,000 psia. The start bottle may be pressurized up to 1000 psia at all temperatures not exceeding 600°R. Under no conditions may the bottle be pressurized to more than 1,310 psia.

3. Measured at stage/engine interface.

4. Cutoff limit may be exceeded during the first 60 seconds of engine operation.

5. This parameter is solely monitored by Rocketdyne (automatic cutoff) GSE. It shall be a minimum of 710°R within 0.5 seconds after mainstage control signal. Maximum of 2,460°R between 0.5 and 3.5 seconds after mainstage control signal. Maximum of 1,910°R for remainder of the test.

6. Cutoff value applies to engine firings when actuators are holding engine.

7. Redline value applies with either hydraulic pump operating.

8. Prestart minimum of 55 psia with auxiliary pump inoperative, 145 psia with auxiliary pump operating under steady state conditions.

9. The fuel pump balance piston cavity pressure must exceed the minimum within 12 seconds after engine start. Twenty seconds after engine start, the cutoff value can be ignored.

10. The oxidizer pump primary seal cavity pressure may exceed 50 psia for any 2.5 second period.

11. When the minimum prestart value is observed, a temperature reading of 50°R or less must also have been obtained by C661.

12. With cryogenics on board if bulkhead internal pressure exceeds 3.5 psia, initiate vacuum pumping. Under ambient conditions if bulkhead internal pressure exceeds 18 psia, initiate vacuum pumping.

APPENDIX 3

NOTES (CONTINUED)

13. Prestart minimum of 1,900 psia is without hydraulic pressurization, 3,500 psia after 30 seconds of auxiliary pump operation.

14. Applicable during simulation firing at Beta III site.

15. Starting five minutes prior to preconditioning of the thrust chamber and continuing until water flow is started, there must be a GN2 purge of 0.1 lb/sec at a minimum temperature of 510°R.

16. This parameter is solely monitored by Rocketdyne GSE. Automatic cutoff is generated when a maximal condition exists of 150 G's rms at 960 to 6,000 cps. 70 milliseconds accumulated and storage time set to a minimum.

17. Prestart limits must be maintained up through 90% thrust.

18. Dwell time in any one position in excess of 2° off null position must not exceed one second duration. Engine position of less than 2° of null must not exceed 2 seconds dwell.

19. Prestart and reline minimum values are 15 percent with auxiliary pump on, 85 percent with auxiliary pump off and system static.

20. Voltage may rise to a maximum of 32 vdc for a period of 60 seconds.

21. Cutoff values apply during transition only, not required for mainstage operation.

22. At engine ignition and within the succeeding 4 seconds, redline maximum will be 115 amps, and cutoff maximum will be 200 amps.

23. Redline maximum will be 13 amps for 200 milliseconds after PU activate.

24. Support link may not exceed ± 3,000 pounds for any 10 second period after the initial 10 second transient period has expired.

25. Automatic cutoff parameter on Rocketdyne GSE with no manual backup.

26. Applicable during confidence testing at Complex Gamma only.

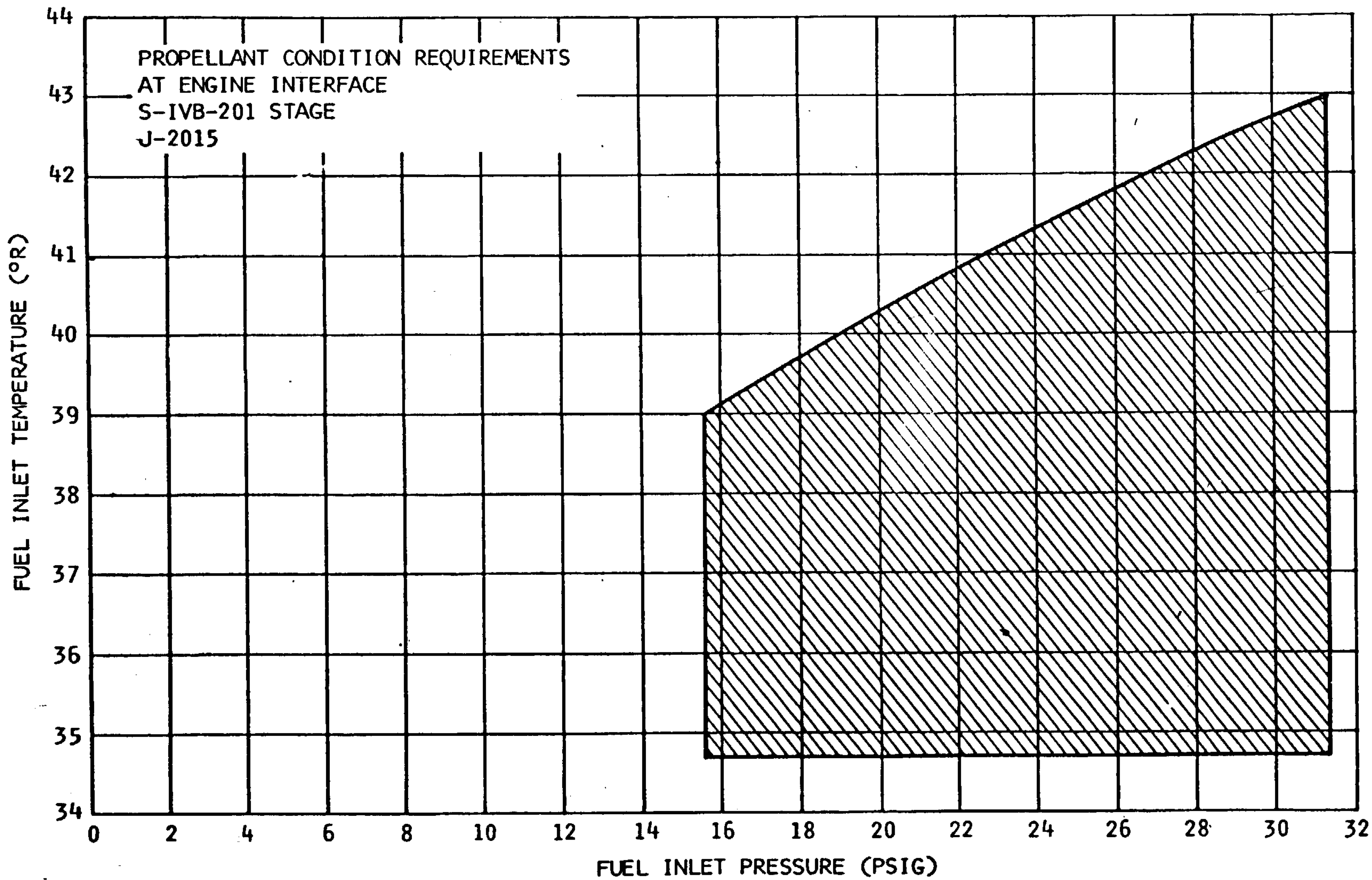


Figure AP-1 Fuel Prestart Critical Limits

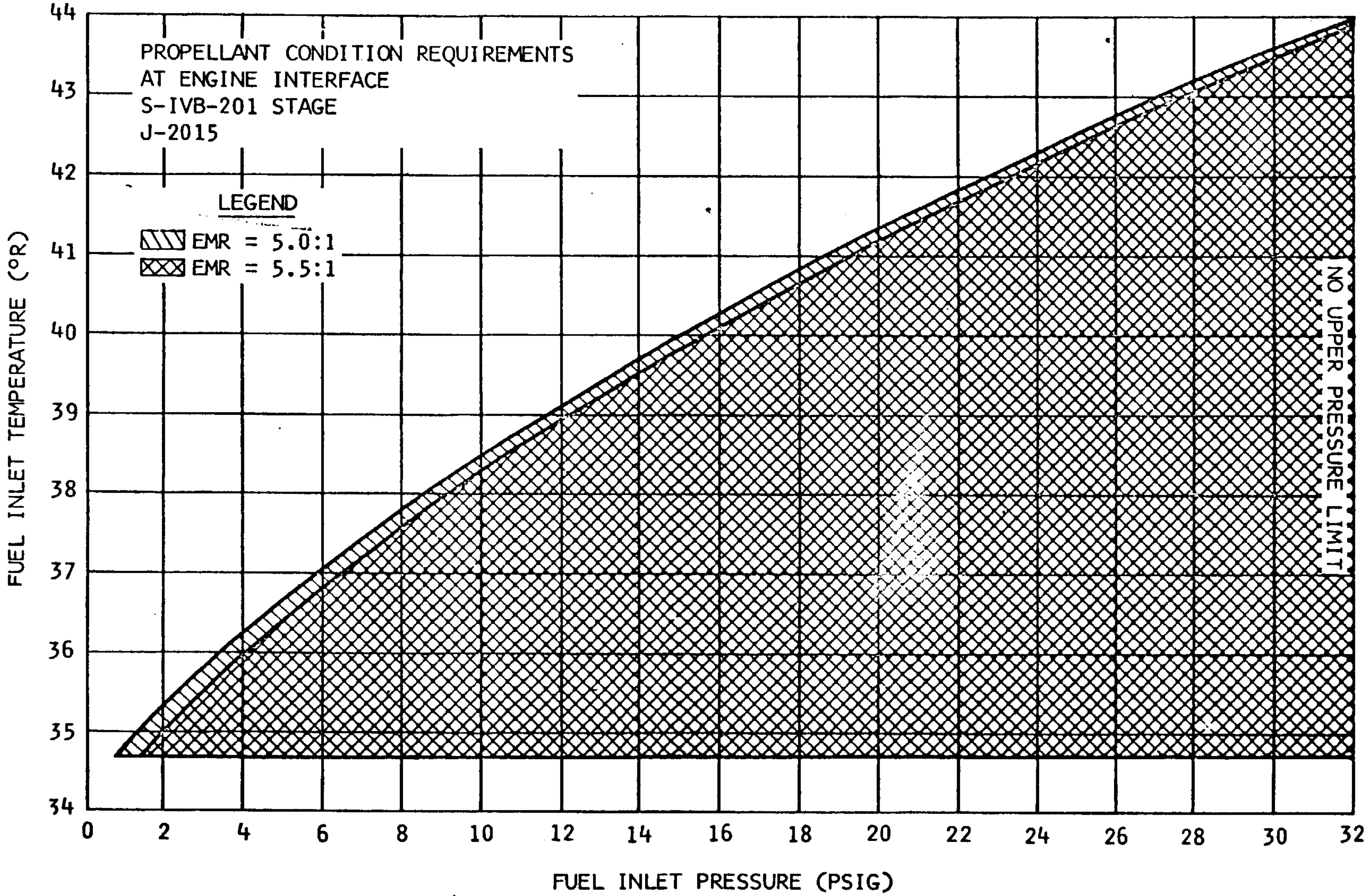


Figure AP-2 Fuel Run Critical Limits

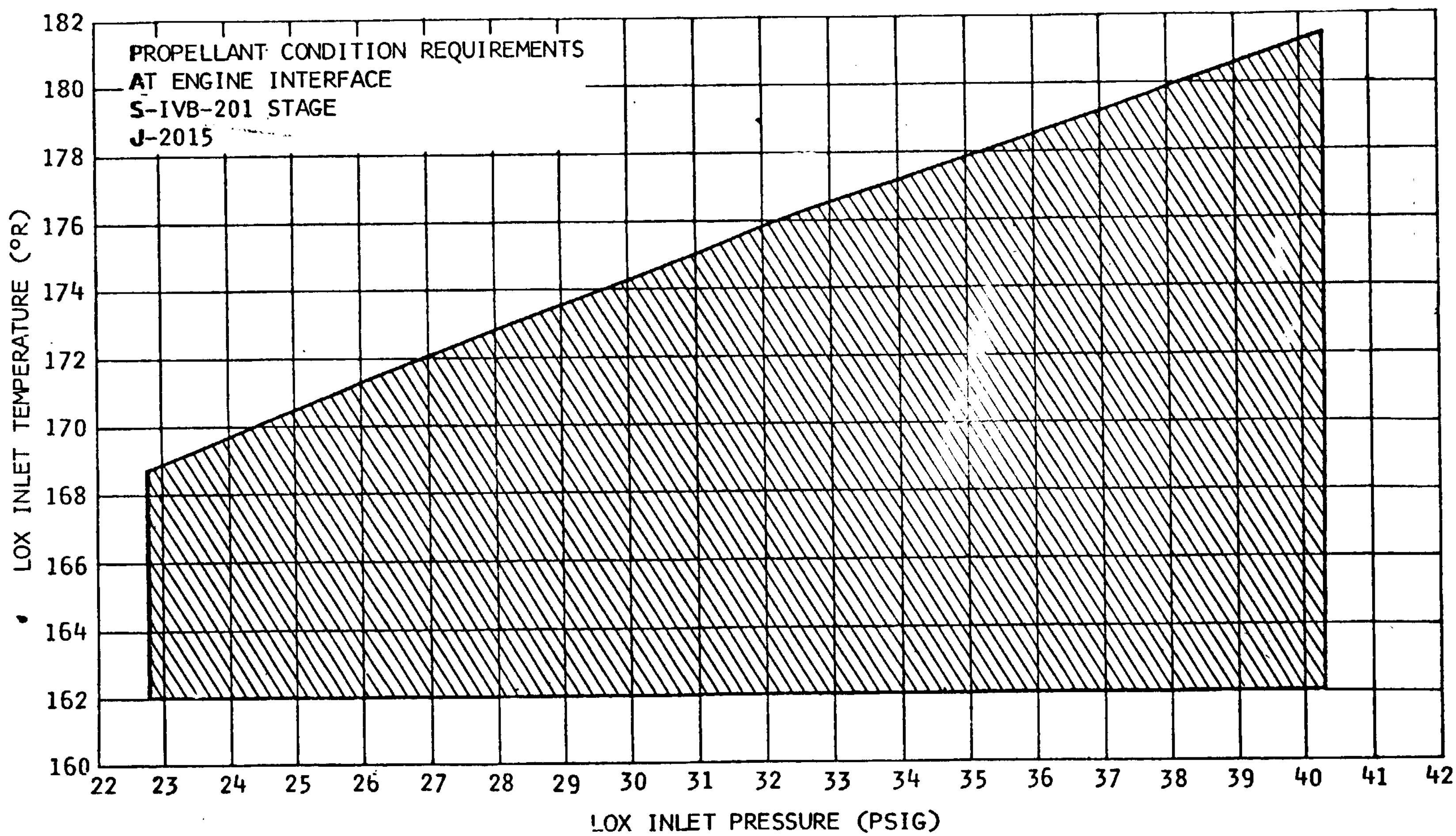


Figure AP-3 LOX Prestart Critical Limits

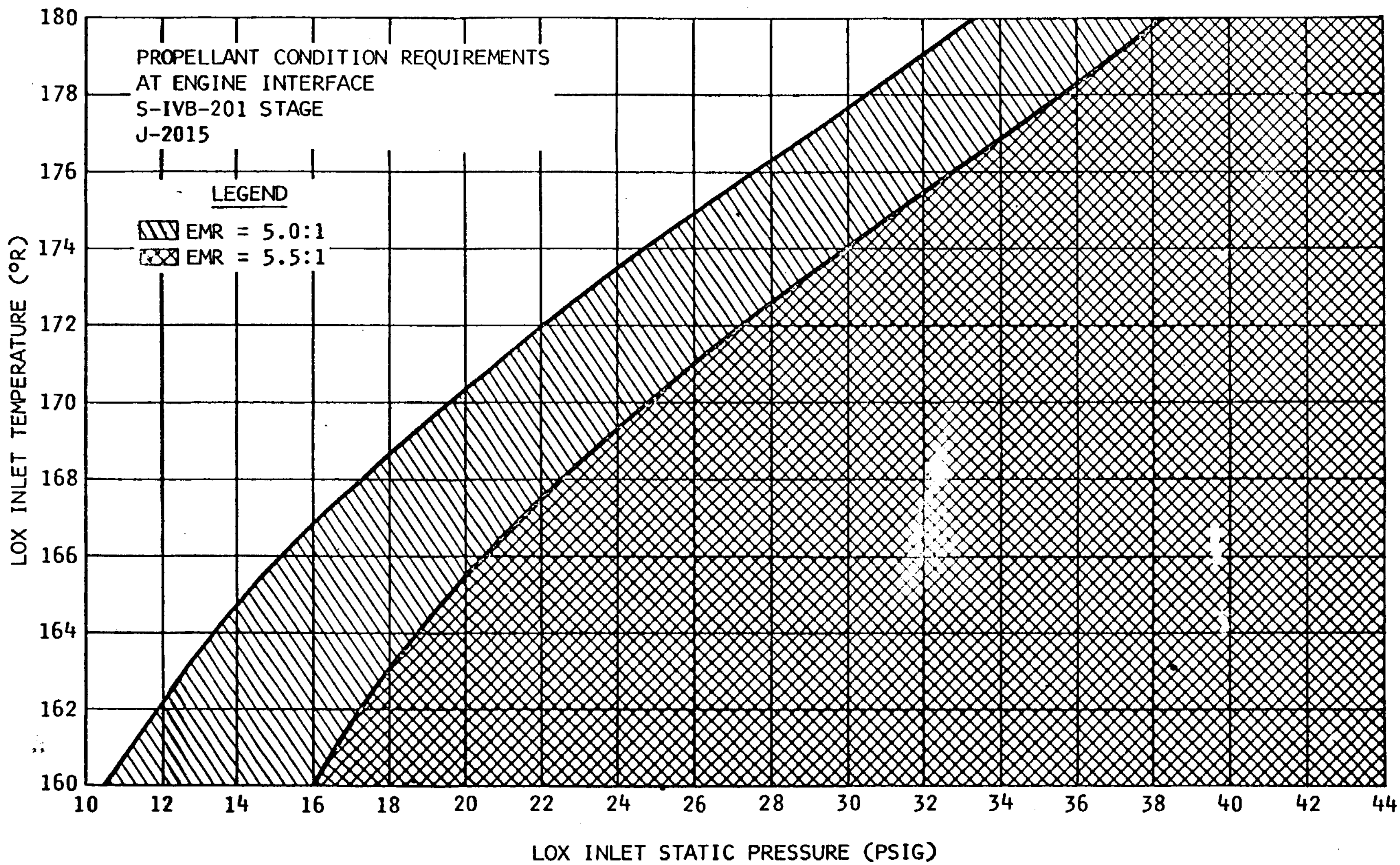


Figure AP-4 LOX Run Critical Limits

APPENDIX 4

COMPLEX BETA
FACILITY AND GROUND SUPPORT EQUIPMENT

APPENDIX 4
COMPLEX BETA
FACILITY AND GROUND SUPPORT EQUIPMENT

COMPLEX BETA FACILITY

MODEL NO.	TITLE
DSV-4B-580	Test Control Center Installation
DSV-4B-581	Fire Detection System
DSV-4B-582	Hydrogen Leak Detection System
DSV-4B-584	Test Stand No. 3 Area Installation
DSV-4B-585	Gas Storage and Utility Area Installation

TEST STAND AREA - MECHANICAL

DSV-4B-303	Forward and Aft Hoist Kit
DSV-4B-308	Fuel Tank Interior Access Kit
DSV-4B-309	Forward Skirt End Protective Cover
DSV-4B-310	Forward Section Vertical Access Kit
DSV-4B-313	Aft Umbilical Kit
DSV-4B-314	Forward Umbilical Kit
DSV-4B-318	Heat Exchanger, Gas
DSV-4B-319	Operational Pneumatic Console "A", Automatic
DSV-4B-320	Automatic Stage Servicing and C/O Pneu. Console "B"
DSV-4B-324	Engine Alignment Kit
DSV-4B-325	Engine Actuator Adjustment Fixture
DSV-4B-326	Environmental Control System Kit
DSV-4B-329	Checkout Accessories Kit
DSV-4B-331	LOX Valve Control Complex
DSV-4B-332	LH2 Valve Control Complex

TEST STAND AREA - MECHANICAL (Continued)

DSV-4B-334	GH2 Umbilical Vent Line Kit
DSV-4B-335	Prop. and Pneumatic Umbilical Lines Installation
DSV-4B-339	Stage Aft Skirt Alignment Kit
DSV-4B-348	LOX Tank Interior Access Kit
DSV-4B-349	Engine Handling Kit
DSV-4B-358	Hydraulic Pumping Unit
DSV-4B-359	Thermo Conditioning System, Forward Skirt Electronics Servicer
DSV-4B-526	Ground Data FM System
DSV-4B-533	PAM/FM Analog System
DSV-4B-540	Dummy Interstage
DSV-4B-543	Single Sidebank Analog System
DSV-4B-546	Support Kit, Truck, Dolly
DSV-4B-601	Cover Kit, Protective, Firing
DSV-4B-609	Access Platform, Dummy Interstage
DSV-4B-610	Vehicle Monitor Panel Assy. S-IVB
DSV-4B-618	Unlatching Restrainer Kit
DSV-4B-626	Checkout and Calibration System Installation
DSV-4B-629	Engine Position Calibration Fixture
DSV-4B-637	Blast Instrumentation System
DSV-4B-639	Engine Bell Extension Servicer
DSV-4B-642	Engine Installation, Diffuser and Stiffener Kit
DSV-4B-643	Adapter Kit Service Unit, Engine Bell Extension
DSV-4B-644	Adapter Kit, Thermo Conditioner

APPENDIX 4
COMPLEX BETA
FACILITY AND GROUND SUPPORT EQUIPMENT (Continued)

TEST STAND AREA - MECHANICAL (Continued)

DSV-4B-648	Engine Safety Cutoff System, Rack Assy.
DSV-4B-658	Engine Area Purge Installation
DSV-4B-664	Facility Power Control and Monitor Panel Assy.
DSV-4B-673	GN2 Purge Supply Control Panel
DSV-4B-685	Signal Simulation Unit
DSV-4B-687	Cryogenic Protection Kit
DSV-4B-689	J-Box, Engine Pump RPM and Flow Breakout
DSV-4B-694	Access Kit, Tank External
DSV-4B-699	Engine Gimbal Control Unit
DSV-4B-700	Portable TV Camera Mount
DSV-4B-705	Cold Plate Drill Fixture
DSV-4B-712	Access Kit, Handling Ring Removal
DSV-4-186	Nitrogen Fill Truck
DSV-4-187	Vacuum Pumping Unit
DSV-4-324	Desiccant Kit, Dynamics

TEST STAND AREA - ROTATIONAL

DSV-4B-300	S-IVB Stage Transporter
DSV-4B-301	S-IVB Stage Cradles
DSV-4B-304	Environmental Protective Cover Kit
DSV-4B-305	Special Tool Kit

TEST STAND AREA - ELECTRICAL

DSV-4B-110	Power System Electrical Component Test Set
DSV-4B-112	PU Component Test Set
DSV-4B-130	Stimuli Signal Conditioner
DSV-4B-131	Response Signal Conditioner
DSV-4B-132	GSE Test Set
DSV-4B-133	Signal Distribution Unit
DSV-4B-134	Vehicle External Power Racks
DSV-4B-135	Safety Item Monitor
DSV-4B-136	Destruct System Test Set
DSV-4B-143	Cable Network Kit, Beta 3 Test Stand
DSV-4B-144	Cable Network Kit, Control Room, All Systems Auto.
DSV-4B-150	Patch Panel Distribution, Box
DSV-4B-170	Battery Power Unit, Simulated Flight
DSV-4B-171	Battery Maintenance Unit, Simulated Flight
DSV-4B-181	Engine Side Load Amplifier Assy.
DSV-4B-184	Electrical Checkout Accessory Kit
DSV-4B-188	APS Simulator
DSV-4B-192	Destruct System Open Loop Command Antenna
DSV-4B-248	PU System Calibration Unit
DSV-4B-253	Auxiliary Distribution Unit
DSV-4B-267	Instrument Unit Substitute
DSV-4B-268	Chassis, Aft Interface Substitute Unit
DSV-4B-284	Distribution Unit, Simulated Flight Battery
DSV-4B-287	Emergency Battery Rack Assy.

APPENDIX 4
COMPLEX BETA
FACILITY AND GROUND SUPPORT EQUIPMENT (Continued)

TEST CONTROL CENTER - ELECTRICAL

DSV-4B-102	PAM/FM/FM, TM Component Test Set
DSV-4B-103	SS/FM, TM Component Test Set
DSV-4B-104	Printed Circuit Card Component Test Set
DSV-4B-105	Computer, General Purpose, D-924-A
DSV-4B-111	Tape Recorder Component Test Set
DSV-4B-115	PCM/FM, TM Component Test Set
DSV-4B-118	Computer Interface Unit
DSV-4B-120	Systems Status Display Console
DSV-4B-121	Test Operator Console
DSV-4B-123	DDAS Ground Station
DSV-4B-125	PAM/FM/FM Ground Station Assy.
DSV-4B-126	SSB/FM Ground Station
DSV-4B-127	Wide Band Magnetic Tape Recorder
DSV-4B-128	Frequency Calibration Unit Rack Assy.
DSV-4B-151	Patch Panel Distribution Box
DSV-4B-153	Range Time Generator
DSV-4B-172	Engine Side Load Recorder
DSV-4B-232	Telemetry Systems Control Console
DSV-4B-233	Remote Pneumatic Control Console
DSV-4B-234	Propulsion System Control Console
DSV-4B-236	Electrical Networks Control Console
DSV-4B-238	Propulsion System Display Unit
DSV-4B-239	Electrical Networks Display Unit

APPENDIX 4
COMPLEX BETA
FACILITY AND GROUND SUPPORT EQUIPMENT (Continued)

TEST CONTROL CENTER - ELECTRICAL (Continued)

DSV-4B-240	Telemetry System Display Unit
DSV-4B-252	Transmitter Test Set
DSV-4B-278	PCM/FM Ground Station
DSV-4B-289	Digital Events Evaluator
DSV-4B-294	Auxiliary Control Console
DSV-4B-296	TM Signal Distribution Unit
DSV-4B-298	System Status Display B/W

APPENDIX 5

COMPLEX GAMMA
APS MODULE TESTING GROUND SUPPORT EQUIPMENT

APPENDIX 5
COMPLEX GAMMA
APS MODULE TESTING GROUND SUPPORT EQUIPMENT

TEST STRUCTURE AREA

MODEL NO.	TITLE
DSV-4B-344	Attitude Control Module Handling Sling
DSV-4B-372	Fuel Valve Complex Control Assembly
DSV-4B-373	Oxidizer Valve Complex Control Assembly
DSV-4B-374	Pneumatic Distribution Complex Control Assembly
DSV-4B-375	Pneumatic Regulation Complex Control Assembly
DSV-4B-537	Module Test Fixture
DSV-4B-592	Test Cells Installation
DSV-4B-593	Test Cells Cable Kit
DSV-4B-598	Propellant and Pneumatic Hose Kit
DSV-4B-634	Service Kit
DSV-4B-635	APS Module Transport Dolly

TEST CONTROL CENTER

DSV-4B-551	Strip Chart Recorder Console (2)
DSV-4B-555	APS Facilities Control Console
DSV-4B-556	APS Module Control Console
DSV-4B-557	Thermocouple Reference Junction Console
DSV-4B-558	Programmable Distribution Console
DSV-4B-590	Test Control Center Installation
DSV-4B-591	Test Control Center Cable Network Kit

APPENDIX 5
COMPLEX GAMMA
APS MODULE TESTING GROUND SUPPORT EQUIPMENT (Continued)

INSTRUMENTATION CENTER

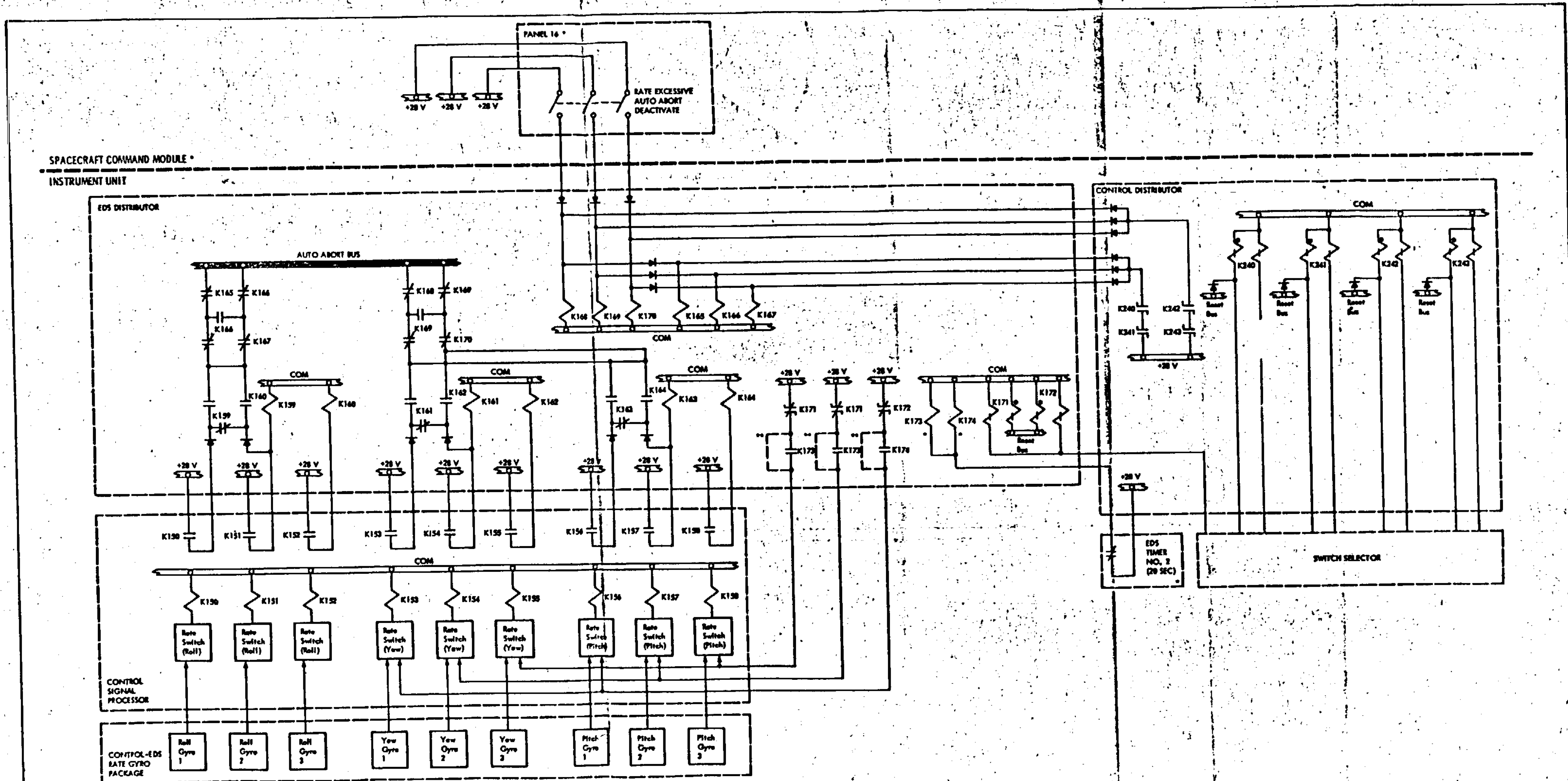
MODEL NO.	TITLE
DSV-4B-547	Instrumentation Calibration and Control Console
DSV-4B-548	Pulse Duration Modulation System Console
DSV-4B-549	Frequency Modulation Recording and Playback System
DSV-4B-550	Magnetic Tape Recorder Console
DSV-4B-551	Strip Chart Recorder Console (3)
DSV-4B-552	Oscillograph Recorder Console
DSV-4B-553	Signal Conditioning Console
DSV-4B-554	Programmable Distribution Console
DSV-4B-588	Instrumentation Center Installation
DSV-4B-589	Instrumentation Center Cable Network Kit

PROPELLANT STORAGE AREAS

DSV-4B-322	APS Mobile Oxidizer Servicer
DSV-4B-323	APS Mobile Fuel Servicer
DSV-4B-560	Storage Area Control Panel (2)

COMPLEX GAMMA FACILITY

DSV-4B-559	Complex Gamma Cable Network Kit



NOTES:
* Not applicable for Saturn Vehicle SA-203.
** Applicable for Saturn Vehicle SA-203 only.
1. Relay numbers shown are for reference only and do not correspond to actual hardware reference designations.
2. All relays are shown in deenergized or reset condition.
3. Reset buses can be energized only from Ground Support Equipment.
4. Wires between Command Module and Instrument Unit pass through Service Module and Lunar Excursion Module adapter.

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Figure 2- Angular Overrate Automatic Abort Functional Schematic

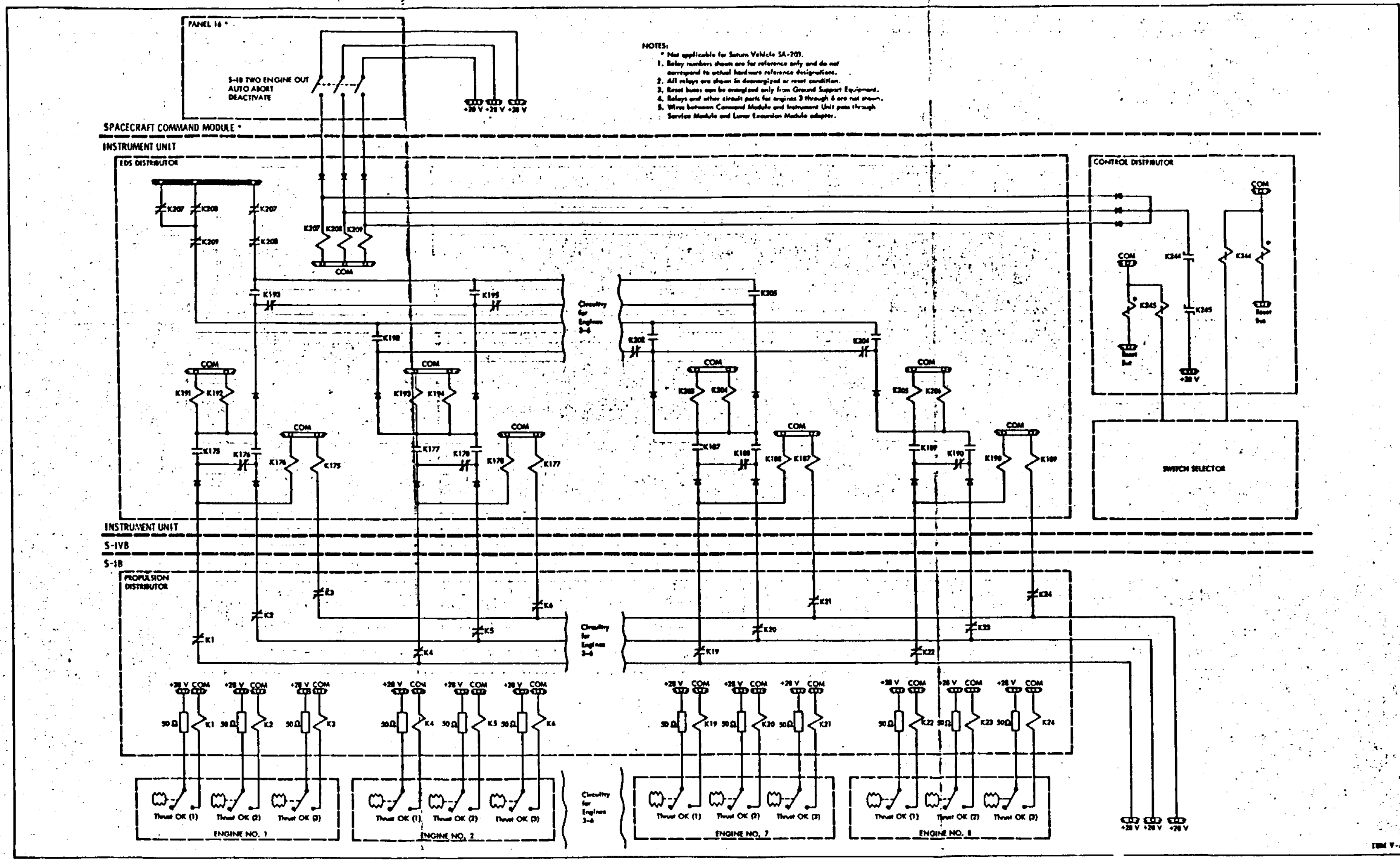
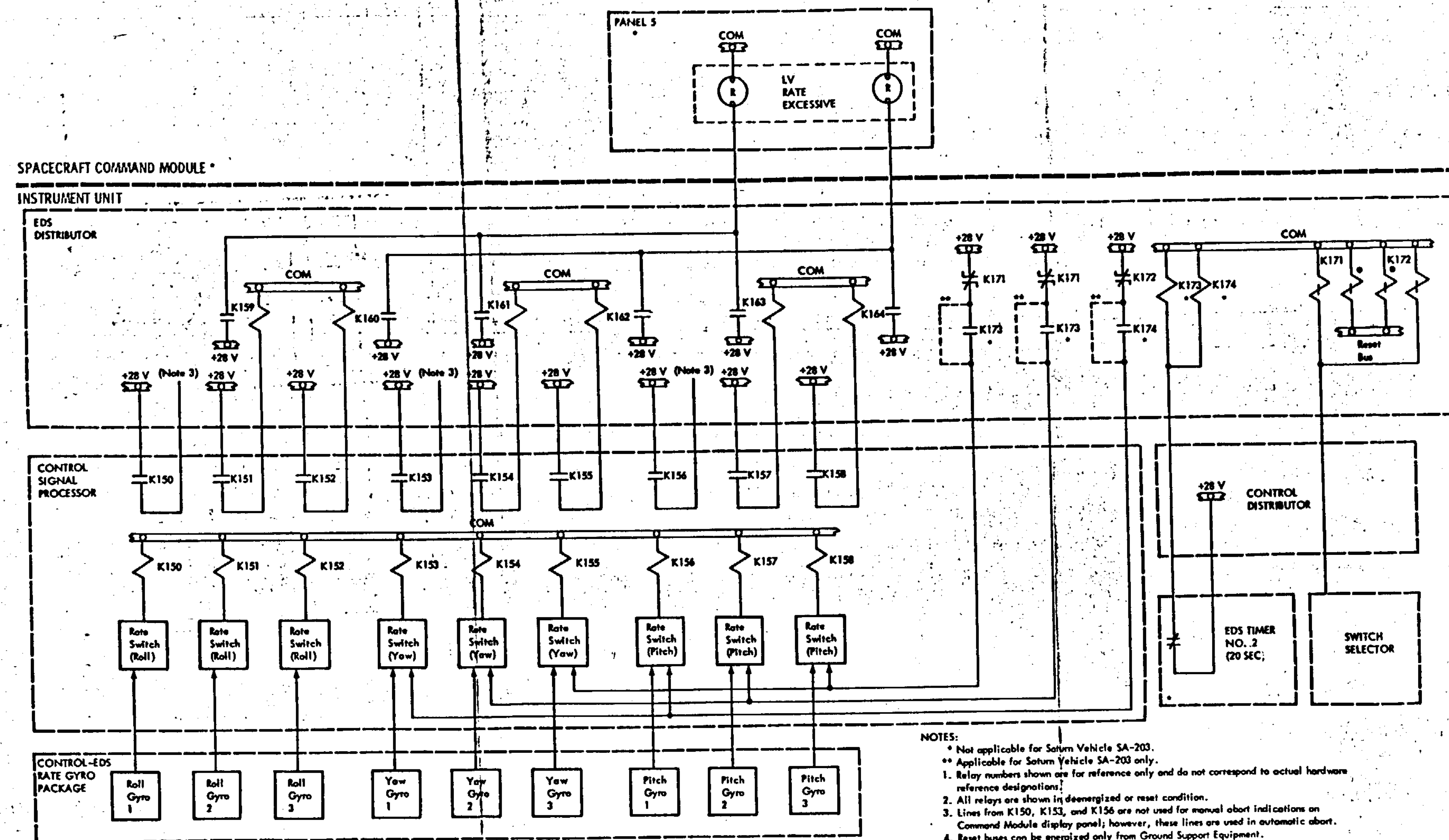


Figure 2-2. Two-Engine-Out Automatic Abort Functional Schematic



NOTES:
* Not applicable for Saturn Vehicle SA-203.
** Applicable for Saturn Vehicle SA-203 only.
1. Relay numbers shown are for reference only and do not correspond to actual hardware reference designations.
2. All relays are shown in deenergized or reset condition.
3. Lines from K150, K153, and K156 are not used for manual abort indications on Command Module display panel; however, these lines are used in automatic abort.
4. Reset buses can be energized only from Ground Support Equipment.
5. Wires between Command Module and Instrument Unit pass through Service Module and Lunar Excursion Module adapter.

Figure 2-3 Angular Overrate Manual-Abort Indication Functional Schematic

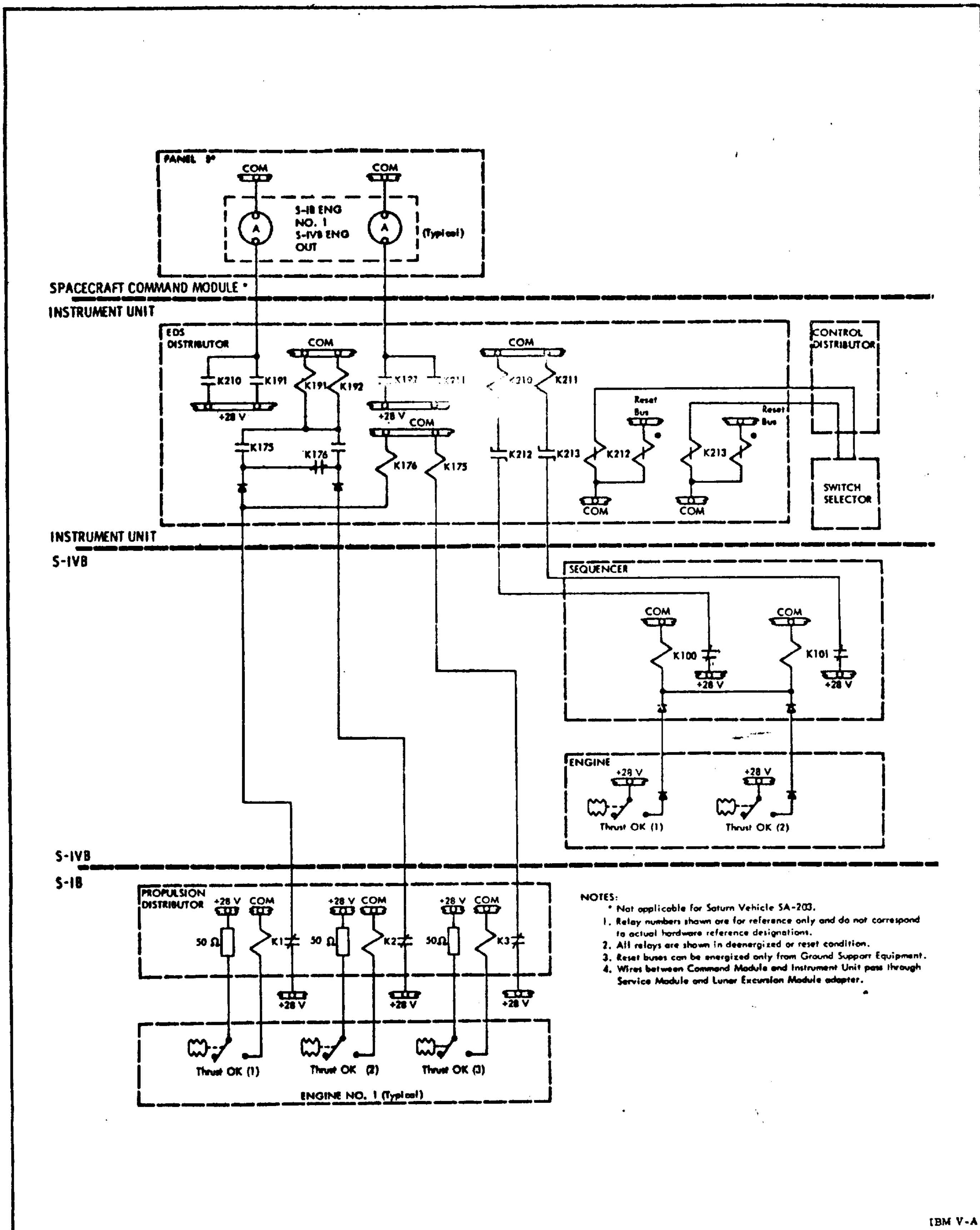
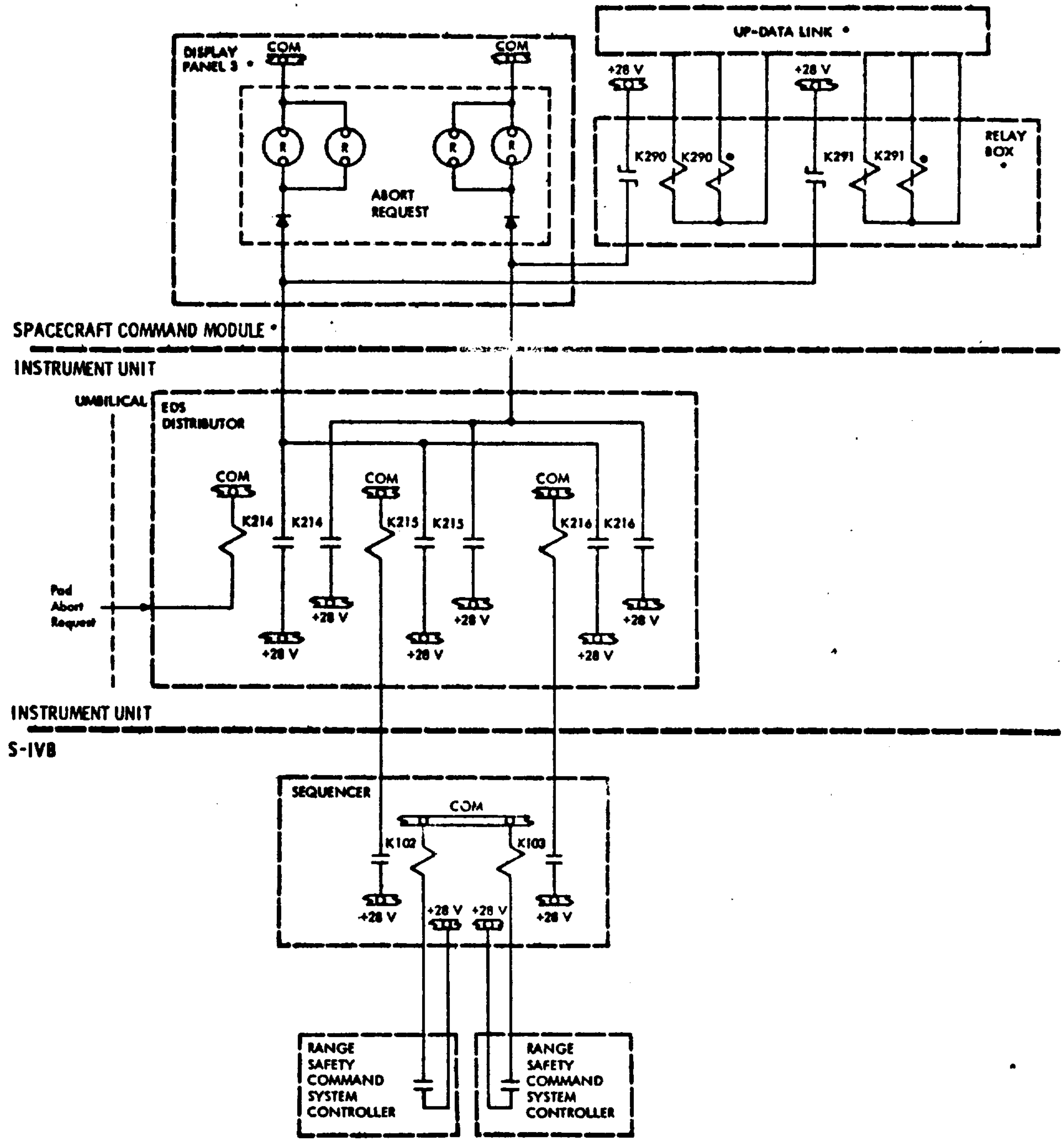


Figure 2-4. Engine Out Manual-Abort Indication Functional Schematic



NOTES:
* Not applicable for Saturn Vehicle SA-203.
1. Relay numbers shown are for reference only and do not correspond to actual hardware reference designations.
2. All relays are shown in deenergized or reset condition.
3. Wires between Command Module and Instrument Unit pass through Service Module and Lunar Excursion Module adapter.

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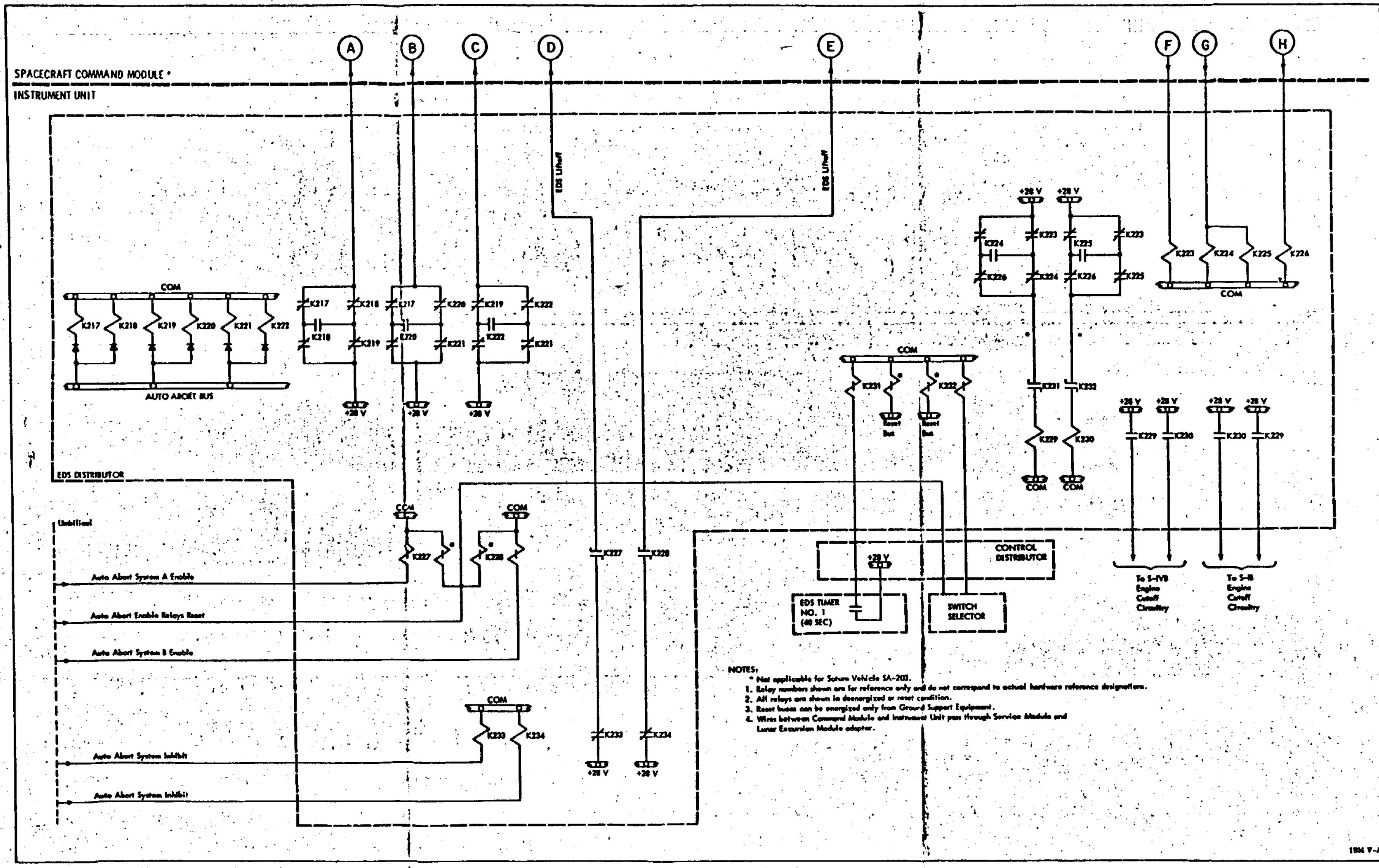
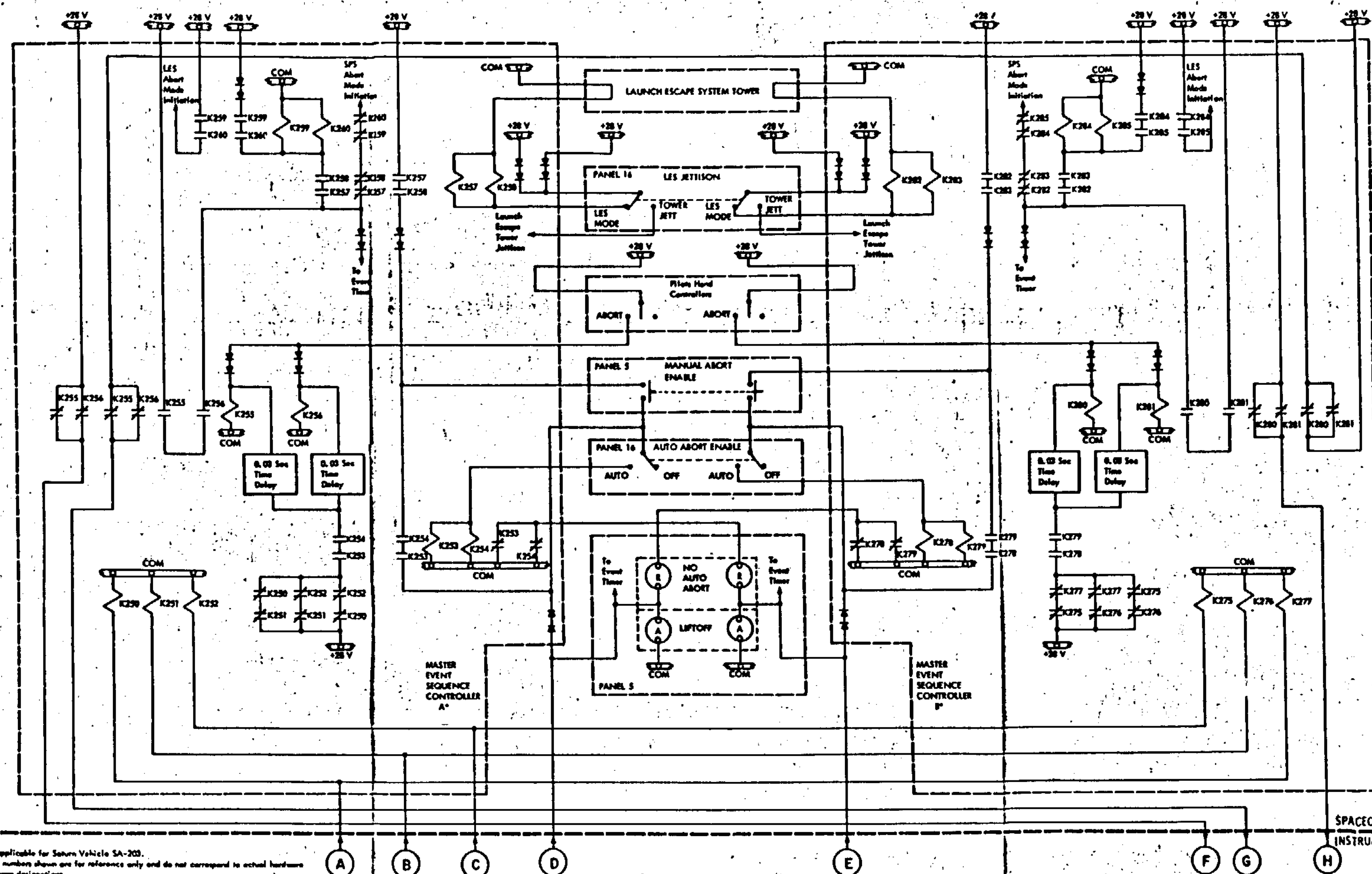
Figure 2-5. Abort Request Indication Functional Schematic



NOTES:
* Not applicable for Saturn Vehicle SA-203.
1. Relay numbers shown are for reference only and do not correspond to actual hardware reference designations.
2. All relays are shown in deenergized or reset condition.
3. Reset buses can be energized only from Ground Support Equipment.
4. Wires between Command Module and Instrument Unit pass through Service Module and Lunar Excursion Module adapter.

Figure 2-6. Abort Sequence Functional Schematic (Sheet 1 of 2)



NOTES:

* Not applicable for Saturn Vehicle SA-203.

1. Relay numbers shown are for reference only and do not correspond to actual hardware reference designations.
2. All relays are shown in deenergized or reset condition.
3. Reset buses can be energized only from Ground Support Equipment.
4. Wires between Command Module and Instrument Unit pass through Service Module and Lunar Excursion Module adapter.

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Figure 2-6. Abort Sequence Functional Schematic (Sheet 2 of 2)

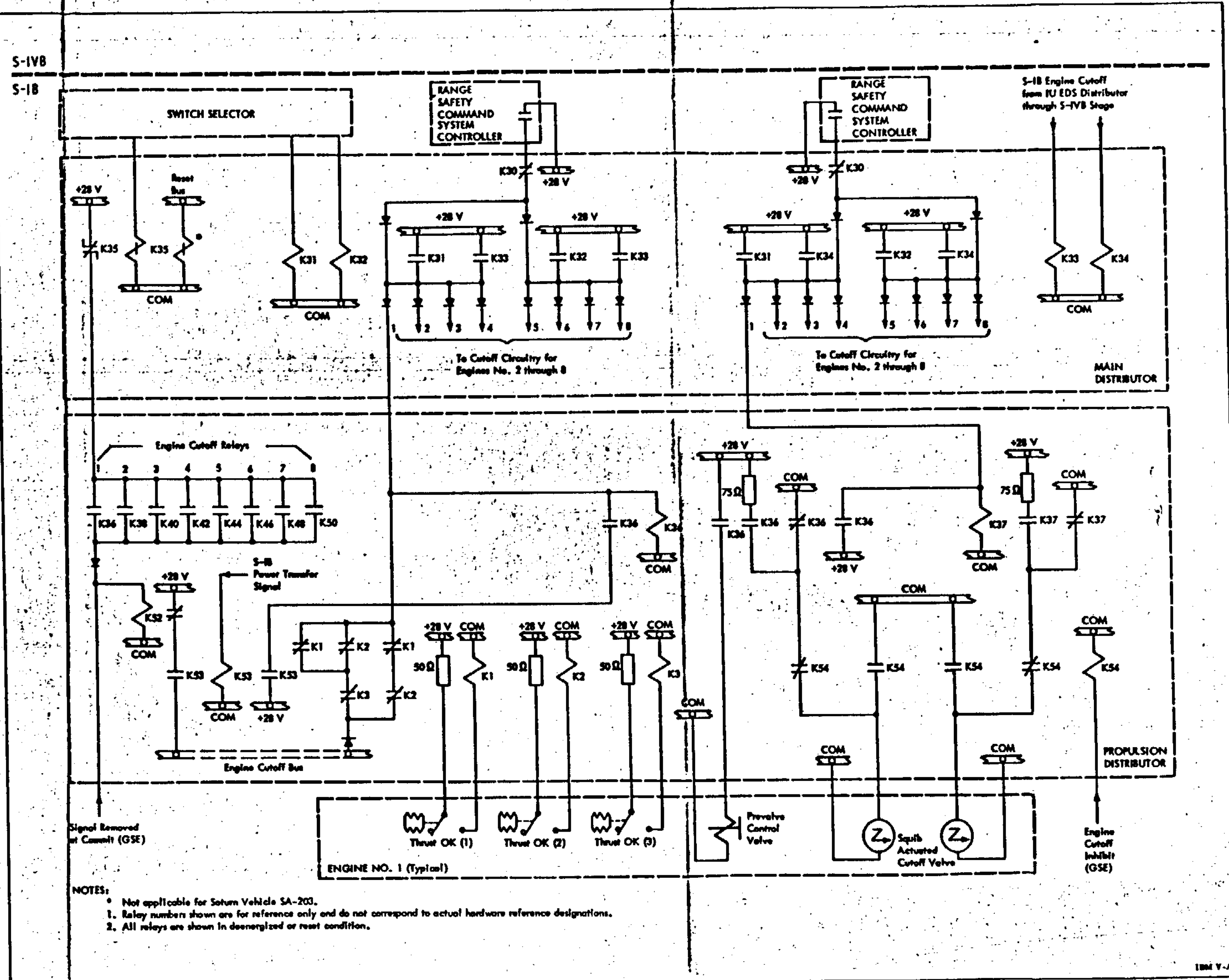

Figure 2-7. S-IB Engine-Cutoff Functional Schematic

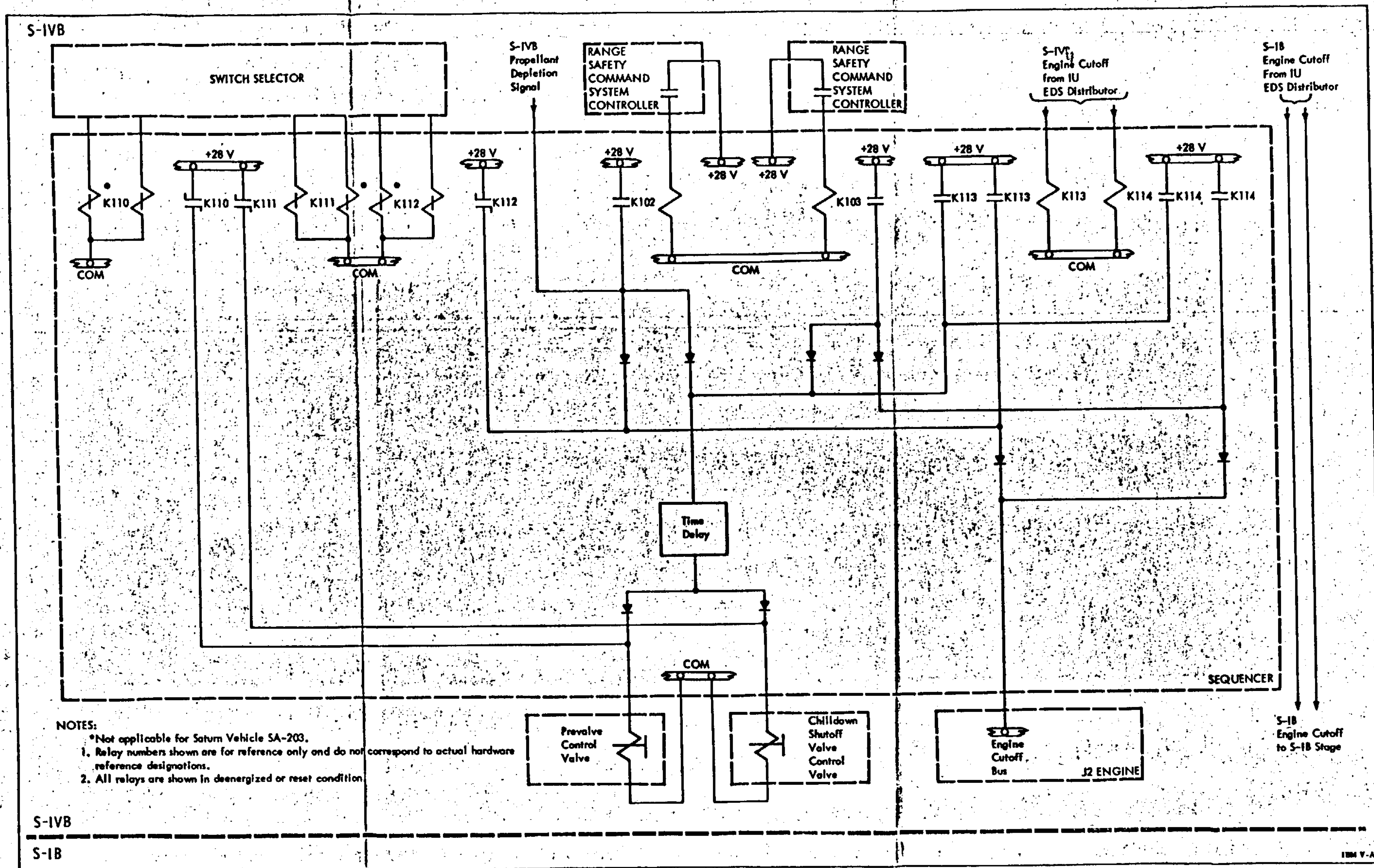

Figure 2-8. S-IVB Engine-Cutoff Functional Schematic